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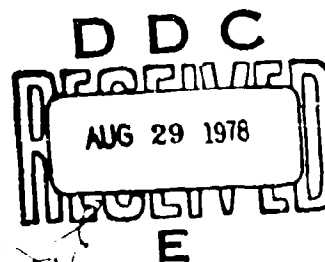


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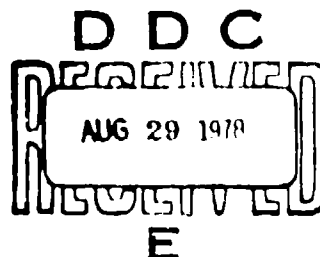
A DYNAMIC ANALYSIS OF THE
MEDIUM TANK BATTALION: VOLUME I

BY

LTC G. P. SCHURTZ, USA
MAJ H. J. LOWE, USA
MAJ J. J. STEELE, USA
JUNE 1978

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and close air support are excluded. Weapons performance characteristics are for those systems in the U.S. and Soviet active inventory. A battalion with 4 tanks in a platoon, 3 platoons in a company, and 4 tank companies in the battalion provides the best organization to defeat a Soviet attack with minimum losses. Target servicing capability, fire distribution, survivability, and flexibility are found to be the best compared to all other alternatives examined.

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EXECUTIVE SUMMARY

Armed with the most modern weapons and significantly increased in size, Warsaw Pact forces presently pose an unprecedented peacetime threat to the viability of the U.S. Army as a deterrent to political and/or military aggression in Central Europe. Challenged by this formidable Pact threat, the U.S. Army is responding with a comprehensive program to develop its capabilities to counter any Soviet thrust into Europe. This program includes extensive postulation of more effective tactical doctrine as explained in the "How to Fight Manuals," a new family of armored fighting vehicles, and continuing efforts to improve command and control as well as combat service support. In addition to making improvements in doctrine, equipment, and leadership, the Army must also respond to the Warsaw Pact threat by optimally organizing its units to exploit the potentialities of these new improvements. The organization of the current tank battalion is essentially the same as that which emerged from World War II: five tanks per platoon, three platoons per company, and three companies per battalion. The purpose of this Study is to analyze, in light of recent improvements, the major combat elements of the Medium Tank Battalion and determine its optimal organization to fight and win on the modern mechanized battlefield.

This Study examines defensive operations of a tank battalion fighting in a conventional, non-toxic environment in Central Europe against a minimum warning attack by Pact armored formations. Alternative tank battalion organizations conducted active defenses astride a series of regimental size avenues of approach, all ideal for a Soviet tank or motorized rifle regiment breakthrough attack. Each battalion had six hours to prepare defensive positions. To test the differing organizations, the Study Group utilized war game simulation employing a computer-assisted manual wargame called BATTLE.

Alternatives selected for testing included all combinations of tank battalion organizations with 3, 4, or 5 tanks per platoon, 3 or 4 platoons per company, and 3 or 4 companies per battalion with an aggregate strength not to exceed 54 tanks. Each alternative included an attached mechanized infantry company and an organic TOW company.

In addition to the organization of the tank battalion, the Study identified four other key factors relevant to the analysis: Soviet attacking force, intervisibility, terrain, and rates of movement. By combining variations of these four factors, the Study Group designed six defensive scenarios which each alternative organization fought. From the battle results, challenges to command and control, and tactical lessons learned, the Study selected a best organization. The final rank order was as follows:

<u>Tanks</u>		<u>Platoons</u>		<u>Companies</u>	<u>Total No. Tanks</u>
4	-	3	-	4	54*
4	-	3	-	3	45
5	-	3	-	3	54
3	-	3	-	3	36
4	-	4	-	3	53*

* Forward Observer and Forward Air Controller tanks eliminated.

Platoons organized with three tanks lacked sustainability and flexibility, while platoons with five tanks were relatively unresponsive and difficult to position. Companies with four platoons overtaxed the company commanders' powers of command and control. The three company battalion experienced serious problems balancing its defense effectively against the tactics of the Soviet breakthrough attack.

Four tank platoons provided the optimum balance among sustainability, responsiveness, and ease of positioning. Three platoons in a company did not overtax the company commanders' powers of command and control. Four tank companies in the battalion made it viable in both an attached and cross attached mode against either a tank or motorized rifle attack. The fourth company clearly provided the battalion commander exceptional flexibility particularly against the most dangerous type Soviet thrust: the breakthrough attack.

The tank and the TOW were exceptionally complementary weapons systems. Employed together correctly, they made a deadly defensive team. The Medium Tank Battalion must have an organic company of long range anti-tank precision guided missiles.

This Study recommends that the U.S. Army reorganize two or more Medium Tank Battalions with four tanks in a platoon, three platoons in a company, four companies in a battalion, and a TOW company for a year long garrison/field test.

ABSTRACT FOR

A DYNAMIC ANALYSIS OF THE MEDIUM TANK BATTALION

An analysis of alternative organizations of the U.S. Army Medium Tank Battalion is conducted using the computer-assisted manual war game BATTLE (Battalion Analyzer and Tactical Trainer for Local Engagements). The purpose of the Study is to determine the best organization to conduct an active defense in a non-toxic conventional environment against Soviet breakthrough tactics. The scope of the Study is limited to operational aspects of a defensive battle conducted by a tank battalion with not more than fifty-four tanks, an organic anti-tank (TOW) company, and an attached mechanized infantry company. Attack helicopter and close air support is excluded. Weapons performance data is that for those systems in the U.S. and Soviet active inventory. A battalion with 4 tanks in a platoon, 3 platoons in a company, and 4 tank companies in the battalion provides the best organization to defeat a Soviet attack with minimum losses. Target servicing capability, fire distribution, survivability, and flexibility are found to be the best compared to all other alternatives examined.

ACKNOWLEDGEMENTS

The authors of this research project wish to acknowledge the assistance we have received from the staff and faculty of the Naval War College and its Center for Advanced Research. We especially appreciated the supporting attitude for non-naval research displayed by the President, Vice Admiral James B. Stockdale, and the Center's Director, Professor Hugh G. Nott.

Our faculty advisors, Colonel Gilbert R. Green, USA and Lieutenant Colonel (P) Harry D. Walker, USA, provided wise counsel. Their door was always open when help was needed. Likewise, the Senior Army Advisor, Colonel Warren A. Spaulding gave us his unqualified support.

Messrs Pete Shugart, Terry Peterson, and Al Kellner, at TRADOC Systems Analysis Activity, White Sands Proving Ground, New Mexico, went to great lengths to teach us the inner workings of BATTLE, from which we were able to establish realistic game rules and procedures to improve the simulation.

Finally, special thanks go to the good people in the trenches without whose help this project would have foundered: Mr. Mel Lieberman, expediter extraordinaire, Mr. Tony Sarro and his Graphic Arts staff for their excellent work, Mr. Joe Domingoes, Center for War Gaming, whose assistance was invaluable when we were constructing terrain boards, Miss Cathy Card, Computer Center of the Center for War Gaming, for accurate

and expeditious key punch support, and Mrs. Carole Sanchez, who cheerfully and efficiently transformed our hieroglyphics into a finished product.

However, we recognize and accept our responsibility for any factual or technical error and that the views expressed herein are those of the authors.

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I. DECISION SITUATION

During the last fifteen years, the United States has witnessed two exceptionally disturbing developments which directly challenge the U.S. Army's ability to conduct a successful defense in Central Europe. The doubts that this has engendered in the minds of Western Europeans concerning the resolve of the United States as the leading nation in NATO threaten vital American interests throughout Europe.

1. Quietly, the Warsaw Pact has markedly increased the size of its forces opposite NATO's Central Army Group, and if they were to launch an assault today, the Soviets could achieve force ratio advantages on the order of four to one opposite selected NATO Corps.

2. Development and deployment of new and improved weapons throughout the Pact forces have wrought dramatic changes in every aspect of modern mechanized warfare.

Immediately following the end of American participation in the Vietnam War, the U.S. Army began responding to the Soviet challenge in Central Europe through research and development, redeployment, and reorganization. The U.S. Army's Training and Doctrine Command (TRADOC) was assigned the mission of studying the present organization of U.S. Army units to see if these units armed with improved weapons could be reorganized into more effective fighting formations. TRADOC in turn initiated the Division Restructuring Study (DRS) to determine optimum organizations for all type U.S. Army units

below the level of Corps. As a separate but related action, the Commanding General of TRADOC, commissioned this Study Group to develop recommendations for the organization and composition of the Medium Tank Battalion as it contributes to the U.S. Army's mission in NATO.

The Soviets, possessing massive mechanized forces and new or improved weapons with vastly enhanced ranges and lethalties, now have the ability to significantly increase the complexity, intensity, and particularly the tempo of the Central European battlefield. If the U.S. Army expects to fight and win on this modern mechanized battlefield, it must not only possess good leaders, well trained troops, and the most modern of weapons, it must also organize its men and new systems into the most effective possible platoons, companies, and battalions.

The purpose of this Study is to analyze the U.S. Army's Medium Tank Battalion and determine the optimum organization for the battalion's major weapon systems. Based upon the results of this dynamic analysis the Study Group will make appropriate recommendations to the Commanding General of TRADOC to meet the Soviet challenge in Central Europe during the mid-range period (1980-1985).

II. THE SYSTEM

The system analyzed is the U.S. Army Medium Tank Battalion conducting an active defense in Central Europe. The tank battalion has an attached mechanized infantry company and both artillery and engineer elements in direct and/or general support.

III. SYSTEM OBJECTIVE

The objective of the U.S. Army Medium Tank Battalion is to destroy Warsaw Pact armored vehicles.

IV. ALTERNATIVES

The Commanding General of TRADOC initially suggested that the Study Group consider all mathematically possible organizations of a tank battalion that had 3, 4, or 5 tanks in a platoon, 3 or 4 platoons in a company, and 3 or 4 companies in the battalion with an aggregate tank strength in the battalion not to exceed 54 tanks. The Commanding General's guidance translated into the following initial alternatives:

Tanks - Platoons - Companies					Sub Total	CO HQS	BN HQ	Total
3	-	3	-	3	27	6	3	36
4	-	3	-	3	36	6	3	45
3	-	4	-	3	36	6	3	45
3	-	3	-	4	36	8	3	47
5	-	3	-	3	45	6	3	54

Later, the Study Group eliminated the Forward Air Controller's tank from the Battalion Headquarters Section and Artillery Forward Observers' tanks from the Company Headquarters

Sections (See Annex R [Tactical Lessons Learned]). This adjustment allowed the addition of the following two alternative organizations:

Tanks - Platoons - Companies					Sub Total	Co HQS	BN HQ	Total
4	-	4	-	3	48	3	2	53
4	-	3	-	4	48	4	2	54

During a 6 March 1978 In Process Review with the CG TRADOC, the Study Group informed him of the decision to drop 3-4-3 and 3-3-4 from further consideration for reasons discussed at length in paragraphs X METHODOLOGY, XII EVALUATION, and XIII INTERPRETATION.

V. HIGHER SYSTEM

a. Description: U.S. Army Brigade organic to the U.S. Army Division.

b. Higher System Objective: The destruction of enemy forces through the conduct of an active defense.

c. Relationship of Higher System to System Under Study: The Brigade is the command and control headquarters for the Medium Tank Battalion. As a result, the tank battalion both submits reports to the Brigade which convey the enemy and friendly situation and responds to Brigade orders.

VI. KEY FACTORS

Key factors or primary variables bounding this analysis are: attacking Soviet force, terrain, visibility, rate of movement, and tank battalion organization. The Study Group

combined these primary variables into six scenarios representative of the six most typical battles Medium Tank Battalions must win in Central Europe if the U.S. Army is to succeed in defeating a Warsaw Pact thrust into Western Europe.

<u>SCENARIO</u>	<u>ATTACKING SOVIETS</u>	<u>TERRAIN</u>	<u>VISIBILITY</u>	<u>RATE OF MOVEMENT</u>
1	Tank Div 1st Ech	Open	Medium	Slow
2	Tank Div 1st & 2d Echelon	Open	Medium	Slow
3	Tank Div 1st Ech	Open	High	Fast
4	Tank Div 1st & 2d Echelon	Open	High	Fast
5	Tank Div 1st Ech	Open	Low	Slow
6*	MRD 1st Echelon	Broken/ Wooded	Medium	Fast

*The battalion gained a mechanized infantry company and lost an organic tank company.

a. Medium Tank Battalion Organization: The Study Group varied only the number of tanks in a platoon, platoons in a company, and companies in a battalion (see paragraph IV ALTERNATIVES). Regardless of the organization of the tanks in the battalions, the Study Group assigned all battalion alternatives the following additional organic, attached, and supporting units:

- (1) An organic TOW Company (12 TOWS),

(2) An organic 4.2 in Mortar Platoon (6 tubes),
(3) An attached Mechanized Infantry Company (12
DRAGONS, 12 LAW Teams),

(4) Immediate fires of a 155mm Battery (M109A1)
from the Field Artillery Battalion in direct support of the
Brigade,

(5) An 8" Howitzer Battalion (M110) in general
support, and

(6) A divisional engineer platoon in direct support.

b. Attacking Soviet Force:

(1) In Scenarios 1, 3, and 5, the attacking Soviet
force was the first echelon of a Tank Division consisting of
a Tank Regiment (3 tank battalions [93 T-62s]) and an attached
Motorized Rifle Battalion (31 BMPs). The Study selected this
attacking Soviet force because it represents the most danger-
ous Division First Echelon attack a tank battalion would
face. The attacking Tank Regiment had the following artillery
support:

- 1 Battalion of 122mm Howitzers (D30) (RAG)
- 1 Battalion of 122mm Howitzers (D30) (DAG)
- 2 Battalions of 130mm Field Guns (M46) (DAG)
- 3 Battalions of 152mm Gun Howitzer (D20) (DAG)
- 1 Battalion of 122mm MRL (BM21) (DAG)

(2) In Scenarios 2 and 4, the attacking Soviet
force represented the first and second echelons of a Tank
Division consisting of two Tank Regiments, the Division

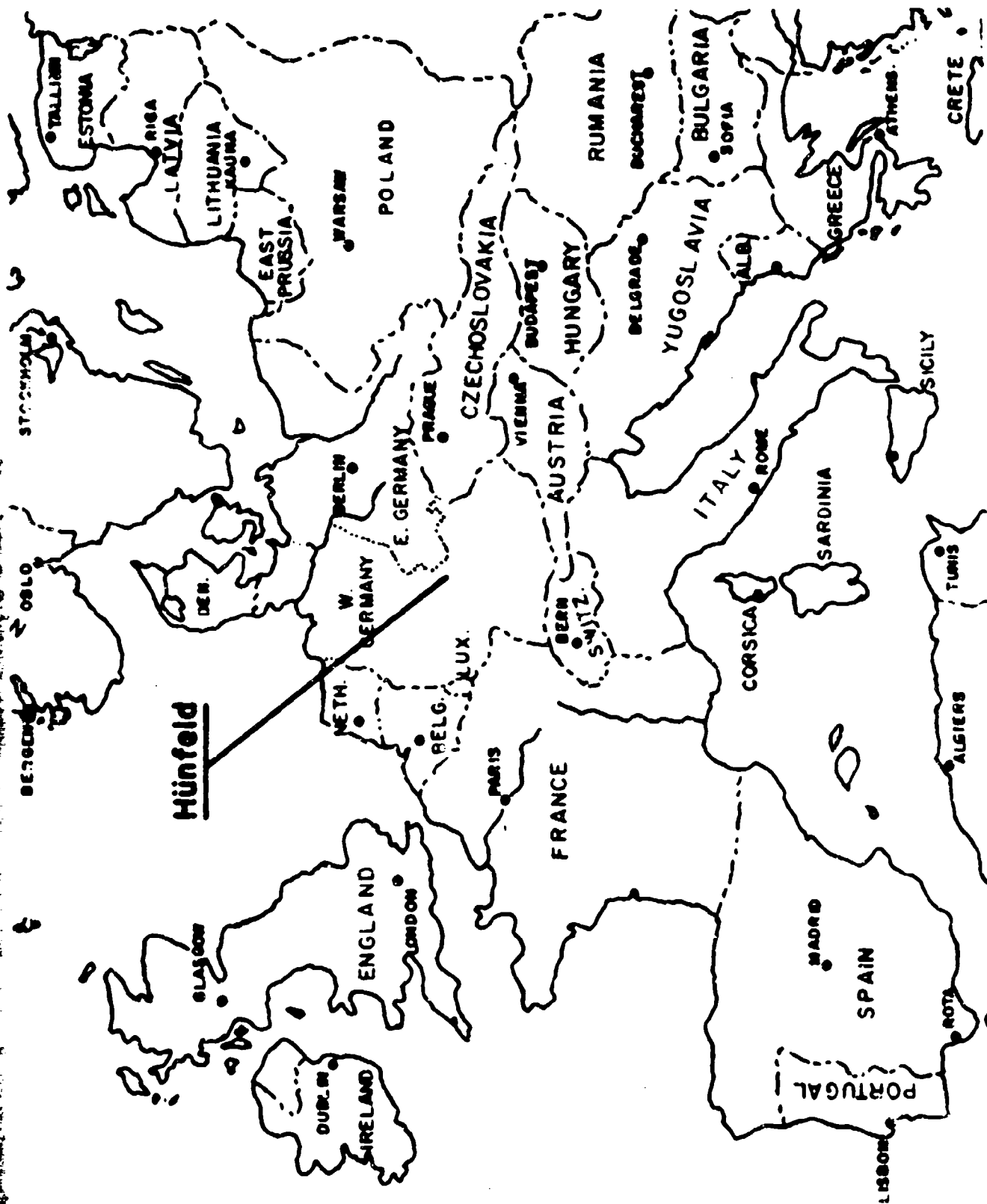
Reserve Tank Battalion, and two attached Motorized Rifle Battalions (seven tank battalions, [217 T-62s] and [62 BMPs]). The Study selected this attacking Soviet force because it represented the most dangerous Division First and Second Echelon attack a tank battalion would face. The Tank Division attack had the following artillery support:

- 2 Battalions of 122mm Howitzers (D30) (RAG)
- 2 Battalions of 130mm Field Guns (M46) (DAG)
- 3 Battalions of 152mm Gun Howitzers (D20) (DAG)
- 1 Battalion of 122mm MRL (BM21) (DAG)

(3) In Scenario 6, the Soviet force represented the first echelon of a Motorized Rifle Division's attack with a Motorized Rifle Regiment (93 BMPs) and an attached Motorized Rifle Division type Tank Battalion (40 T-62s). The Motorized Rifle Regiment had the following artillery support:

- 1 Battalion of 122mm Howitzers (D30) (RAG)
- 1 Battalion of 122mm Howitzers (D30) (DAG)
- 2 Battalions of 130mm Field Gun (M46) (DAG)
- 3 Battalions of 152mm Gun Howitzer (D20) (DAG)
- 1 Battalion of 122mm MRL (BM21) (DAG)

c. Terrain: The Study Group selected terrain Northeast of Hunfeld, West Germany, on which to conduct the test (See Map, page 8). This area was chosen because its gently rolling, lightly wooded hills represent ideal terrain for a Soviet breakthrough attack (the most dangerous attack for NATO ground defenses). With one exception, the Study Group varied the terrain for each scenario (See ANNEXES E, F, G, H, I, and J).



d. Visibility: On this gently rolling terrain, visibility more than any other key factor determined the tactics and tempo of the battlefield.

(1) For Scenarios 1, 2, & 6, the Study established a visibility of 2200 meters, the average daylight visibility for Central Germany along the East-West border.

(2) For Scenarios 3 and 4, the Study established ideal weather conditions with a visibility of 3000 meters (the greatest range at which any direct fire weapon system can fire effectively).

(3) For Scenario 5, the Study established a visibility of 1000 meters for two reasons:

(a) During early morning daylight hours, Central Europe often experiences substantial ground fog. While this fog varies significantly at different altitudes, 1000 meters is a good average for visibility during this period of the day.

(b) The effective range of most infrared and light amplification night firing sights is approximately 800 to 1000 meters. Therefore, 1000 meters is a realistic visibility for a night attack.

e. Rates of Movement: The speed of combat vehicles in Central Europe is totally dependent on trafficability and visibility. Based upon extensive personal experience, the Study Group selected two rates of movement:

<u>Scenario</u>	<u>Weather/Visibility</u>	<u>Trafficability</u>	<u>Rate of Movement</u>
1	Rain/2200 meters	Wet	Slow
2	Rain/2200 meters	Wet	Slow
3	Clear/3000 meters	Dry	Fast
4	Clear/3000 meters	Dry	Fast
5	Fog/1000 meters	Wet	Slow
6	Haze/2200 meters	Dry	Fast

<u>Slow Rate</u>	<u>Fast Rate</u>	<u>Type Vehicle</u>
7.5MPH (12KPH)	11MPH (18KPH)	Track Vehicle Moving Cross Country (Sustained)
7.5MPH (12KPH)	20MPH (32KPH)	Track Vehicle Moving Cross Country (In a Dash)
7.5MPH (12KPH)	15MPH (24KPH)	Track Vehicle Moving Under Fire
4MPH (6.4KPH)	7.5MPH (12KPH)	Track Vehicle In the Assault (Firing)
12MPH (19KPH)	30MPH (48KPH)	Track Vehicle Moving on the Road
15MPH (24KPH)	40MPH (64KPH)	Wheel Vehicle Moving on the Road
4MPH (6.4KPH)	4MPH (6.4KPH)	Dismounted Personnel Running (first 3 min.)
2.5MPH (4KPH)	2.5MPH (4KPH)	Dismounted Personnel (Sustained)

f. ANNEX A (Assumptions) contains a detailed list of all assumptions which bound the problem.

VII. MEASURE OF EFFECTIVENESS (MOE)

The Measure of Effectiveness is the number of Warsaw Pact armored vehicles destroyed.

VIII. MEASURE OF COST (MOC)

The Measure of Cost is the percentage of U.S. combat power lost (Normalized).

IX. CRITERIA

a. Criterion A: For Scenarios #1 through #6, the Study Group fixed effectiveness, measured cost, and rank ordered alternatives from least to greatest costs. (See paragraph

XII EVALUATION for Criterion A Cost and Effectiveness Models)

b. Criterion B: Scenarios #2 and #4, however, were unlike the other four scenarios in that while all alternative battalion organizations defeated the first echelon of the Tank Division's two echelon attack, only one organization also defeated the second echelon's attack. In all other iterations, some tactical consideration (e.g., a turned flank or a penetrated center) forced the battalion to hand off the battle before the defeat of the second echelon. In order to more accurately measure performance of the various alternatives, the Study Group applied an additional criterion to Scenarios #2 and #4 by fixing cost and measuring the effectiveness achieved. (See XII EVALUATION for Criterion B Cost and Effectiveness Models)

X. METHODOLOGY

a. To conduct the 36 iterations that constitute the tests of the alternatives, the Study Group used the Battalion Analyzer and Tactical Trainer for Local Engagements (BATTLE), developed by Training and Doctrine Command's Systems Analysis Agency (TRASANA), to simulate the battles. BATTLE, a computer assisted, manual war game, has four components: (1) scale model terrain boards of a specific geographic area, (2) a set of miniature weapons systems, (3) a minicomputer, and (4) a software package.

(1) The Study Group constructed terrain boards for 80 kilometers of terrain North and Northeast of Hunfeld (NA5414).

By using projections of color positives (scale 1:50,000) on styrofoam, cartographers reproduced in three dimension all natural and man-made topographic features of the area. These terrain boards have a horizontal scale of one inch equal to 50 meters and a vertical scale of one inch equal to 40 meters. Accurate terrain models were critical to the determination of intervisibility.

(2) The Study Group purchased miniatures of every weapons systems played on the battlefield. The scale of these models, however, exceeded the scale of the terrain by a factor of four. (To compensate for intervisibility distortion created by the difference in scale of both the terrain and vehicles the Study Group used the right front fender to represent the actual height and location of the vehicle.)

(3) The minicomputer comprises the major element of the model and includes: (1) Central processing unit, with 64K, 8-bit bytes, (2) Dual-disk drive, 2 Discs at 262K, 8-bit bytes, (3) Cathode Ray Tube Console and Keyboard, (4) High-speed printer, (5) High-speed punch/mark sense card reader.

(4) BATTLE's software, stored on flexible disks used in the dual-disk drive, performs four basic functions - data management, game/computer initialization, action processing, and post processing.

(a) Data management incorporates the storage of both U.S. and Soviet weapons systems performance data from Army Materiel Systems Analysis Activity.

(b) Initialization requires the players to define to the computer: Soviet and U.S. organizations, fire support forces, minefield composition, preparatory fires, and items for recording the exercise.

(c) Action processing uses the data base to evaluate and announce results of player moves and engagements.

(d) Post processing provides a print-out of the results of the game. (See ANNEX B [Explanation of Methodology]).

b. As an analytical tool, BATTLE is at its best when the opposing force players are highly experienced with the organizations, equipment, and tactics being studied. Because the players' judgment enters into the game continuously, BATTLE inherently possesses enough flexibility to allow broadly experienced individuals to make the conflict on the terrain boards approach the reality of war. Consequently, player experience is the paramount factor in the methodology of BATTLE. (See ANNEX D [Biographical Sketches])

c. Since NATO must first win a defensive battle in Central Europe before it can hope to conduct offensive operations, the Study Group elected to test alternative organizations in the active defense.

d. Initially, the Study played five alternatives (3-3-3, 4-3-3, 5-3-3, 3-3-4, and 3-4-3) in Scenarios #1 and #2.

(1) Because 3-4-3 proved cumbersome and produced poor results, the Study Group decided to eliminate it from further consideration (See ANNEX O [Non-Quantifiable Factors] and XII EVALUATION).

(2) After running Scenarios #3 and #4, the Study Group saw from the performance of 4-3-3 and 3-3-4 exceptional merits in the four tank platoon and four company battalion. Therefore, the Study added 4-3-4 as an alternative (deleting FO and FAC tanks to get the aggregate strength to 54 tanks).

(3) Concomittantly, the Study eliminated 3-3-4 from further study because 3-3-3 adequately represented the three tank platoon alternative and 4-3-4 adequately represented the four company option.

(4) Finally, at the request of the Division Restructuring Evaluation Office, Combined Arms Combat Development Agency, the Group added 4-4-3 as an alternative.

XI. BATTLE RESULTS

Aside from practice iterations used to train the players in the mechanics of BATTLE, the Study Group conducted 36 iterations. ANNEXES E, F, G, H, I, and J contain brief narratives of each battle, with overprinted maps of force dispositions, statistical summaries, and logs of the vehicles killed.

XII. EVALUATION

a. Criterion A (Scenarios #1 through #6) (Fix effectiveness; measure cost)

(1) Effectiveness Model

(a) Effectiveness equals killing 50 percent of the Soviet vehicles organic to the attacking regiment(s).

(1) Scenarios 1, 3, and 5 effectiveness equals killing 47 T-62s.

(2) Scenarios 2 and 4 effectiveness equals killing 109 T-62s.

(3) Scenario 6 effectiveness equals killing 47 BMPs.

(b) Current Soviet doctrine holds that after a regiment has lost 50% of its force it halts its advance and assists the passage of following units. In a Soviet breakthrough attack, once a Soviet regiment loses 50% of its organic vehicles, the lead two battalions have too little leadership and too few combat vehicles to continue the attack.

(2) Cost Model

(a) In order to measure and compare losses suffered by different organizations, the Study Group developed a Combat Power Index, based on the professional experience of the Study Group members. Combat power coefficients (CPC) were assigned to those armor defeating systems which were a part of all organizations. They represent a measure of utility of a system considering its capabilities and limitations and were assigned on a scale of 0.0 to 1.0. These CPC are:

M60A1 - 0.7 utils

TOW - 0.4 utils

DRAGON = 0.2 utils

LAW = 0.1 utils

(See ANNEX C [Combat Power Index] for a detailed rationale for these CPC).

(b) The Study then calculated the combat power of each organization (CP_{ORG}) by using the following formula:
$$CP_{ORG} = (.7) (\#M60A1s \text{ assigned}) + (.4) (\#TOWs \text{ assigned}) + (.2) (\#DRAGONS \text{ attached}) + (.1) (\#LAWS \text{ attached})$$

(c) Costs to an organization consisted of the summation of systems lost during the battle weighted by each system's CPC in utils and expressed as a percentage of its initial combat power.

$$\% CP_{cost} = \frac{[(.7) (\#M60A1 \text{ Lost}) + (.4) (\#TOWs \text{ Lost}) + (.2) (\#DRAGONS \text{ Lost}) + (.1) (\#LAWS \text{ Lost})]}{CP_{ORG}}$$

(d) In order to compare costs across different organizations and not unfairly penalize those with lower initial combat power, the Study Group developed a separate Cost Model that normalized losses by holding combat power coefficients constant for all systems in all organizations and comparing those losses against the combat power of a H-series organization ($CP_{5-3-3} = 46.2$). Therefore:

$$CP_{Normalized} = \frac{[(.7) (\#M60A1 \text{ Lost}) + (.4) (\#TOWs \text{ Lost}) + (.2) (\#DRAGONS \text{ Lost}) + (.1) (\#LAWS \text{ Lost})]}{CP_{5-3-3}}$$

(See ANNEX N [Evaluation] for cost data and expanded discussion of the Cost Model)

(3) Rank Order by Least Percentage of Normalized
Combat

Rank	Scenarios		
	1	2	3
1st	4-3-4 (3.0)	4-3-4 (21.2)	4-3-4 (3.2)
2d	4-3-3 (16.9)	4-3-3 (45.4)	4-4-3 (4.5)
3d	3-3-3 (28.1)	3-3-3 (47.4)	5-3-3 (7.1)
4th	4-4-3 (36.4)	4-4-3 (63.0)	4-3-3 (11.7)
5th	5-3-3 (41.3)	5-3-3 (68.2)	3-3-3 (13.4)

Rank	Scenarios		
	4	5	6
1st	4-3-4 (21.4)	4-3-3 (10.6)	4-3-3 (6.9)
2d	4-4-3 (31.8)	4-3-4 (13.6)	4-3-4 (10.2)
3d	5-3-3 (37.4)	5-3-3 (18.2)	5-3-3 (11.7)
4th	3-3-3 (45.0)	3-3-3 (27.3)	3-3-3 (42.3)
5th	4-3-3 (47.6)	4-4-3 (29.0)	4-4-3 (47.2)

(4) Rank Order of Alternatives by Criterion A using
average percentage of normalized Combat Power Lost in battle
iterations over all scenarios:

4-3-4 (12.1)
4-3-3 (23.2)
5-3-3 (30.7)
3-3-3 (33.9)
4-4-3 (35.3)

b. Criterion B (Scenarios #2 & #4) (Fix cost, measure
effectiveness)

(1) Effectiveness Model

(a) The Study calculated the combat power co-
efficients for T62 and BMP similarly to those for M60A1 and
TOW in Criterion A Cost Model:

T62 .7
BMP .4

(See ANNEX C [Combat Power Index])

(b) Effectiveness = (.7) (number of T-62s destroyed) + (.4) (number of BMPs destroyed) = Combat power utils

(2) Cost Model

(a) Cost equals the loss of 50 percent of the total utils possible in a battalion normalized to a 54 tank battalion.

(b) Scenarios #2 and #4 Cost = 23.1 utils lost (See ANNEX N [Evaluation])

(3) Rank Order by Most Soviet Combat Power Killed

Rank	Scenario	
	2	4
1st	4-3-4 (91.1)	4-3-4 (130.4)
2d	3-3-3 (84.3)	5-3-3 (93.9)
3d	4-3-3 (84.1)	4-4-3 (93.)
4th	5-3-3 (80.8)	3-3-3 (89.9)
5th	4-4-3 (60.5)	4-3-3 (73.2)

(4) Rank Order of Alternatives, using the organization average effectiveness attained over both scenarios:

4-3-4 (110.75)
 5-3-3 (87.35)
 3-3-3 (87.10)
 4-3-3 (78.65)
 4-4-3 (76.75)

c. Rank Order of Alternatives by combining Criterion A and B:

4-3-4
 4-3-3
 5-3-3
 3-3-3
 4-4-3

d. Alternative Selected: 4-3-4

e. Analysis of Variance (Annex M (Analysis of Variance Computation))

(1) A two-way analysis of variance on U.S. losses (cost), both Combat Power (Normalized) and M60A1, revealed that results obtained by scenario varied dramatically. At the 95% confidence level, the F-Statistic (F_1) greatly exceeded the acceptable value. In other words, variations in terrain, visibility, rates of movement and threat changed the nature of the battle, as expected.

(2) However, the F-Statistic (F_2) for all organization battles across all scenarios was within the acceptable value at the 95% confidence level, which meant that variations in organization could not be rejected and further testing is called for before acceptance or rejection is warranted. Inspection of organization means (\bar{x}) and standard deviation (S) would tend to indicate that 4-3-4 was outside the distribution for the other alternative battalion organizations:

	\bar{x}	S
4-3-4	12.1	8.21
4-3-3	23.18	18.36
5-3-3	30.65	22.47
3-3-3	33.92	13.22
4-4-3	35.32	19.55

(3) Hence, further analysis was conducted on three measurements of Loss Exchange Rate (LER). In all cases, the F-Statistic (F_2) for organization means exceeded the F-Statistic at the 95% confidence level, which indicated \bar{x} outside

the distribution might be attributed to differences in organizations - specifically as it pertains to target servicing capability of the total force.

(4) The F-Statistic for scenario means (F_1) was less than its $F_{.05}$, which meant that variations between scenarios might be attributed to chance. Intuitively this result could be expected. Variations in LER among scenarios are to be expected when key factors are varied. Examination of the data confirms this hypothesis.

(5) Rank order of alternatives by LER was:

Organ	Mean LER (Total Force)
4-3-4	7.24
5-3-3	3.89
4-3-3	3.38
4-4-3	3.31
3-3-3	2.76

4-3-4 is obviously the organization outside the distribution and its target servicing capability appears to be a result of organization.

f. Sensitivity Analysis

(1) Experimental Error: Dramatic shifts in the Combat Power Coefficients (CPC) should reveal any residual sensitivity of the results to the CPC chosen. The Study assumed the results of 5-3-3 were accurate and then calculated that the degree of allowable error for 4-3-4's results is 150 percent. For 4-3-3 the degree of allowable error is 32 percent. (See ANNEX S [Sensitivity Analysis Computation]). In all iterations, the Study rigorously and uniformly

applied an extensive set of game rules (See ANNEX A [Assumptions]). Efforts to minimize U.S. losses were prudent, tactically sound, and consistent. Hence, the possibility of these magnitudes of error is minimal.

(2) The analysis varied the key factors of visibility, terrain, attacking Soviet force, and rate of movement (paragraph XI KEY FACTORS) and tested each organization uniformly in each scenario. Consequently, sensitivity analysis of these key factors was part of the basic analysis.

g. Contingency Analysis

After Central Europe, the next most likely geographic areas into which the U.S. Army might employ the Medium Tank Battalion as part of a Heavy Division would be the Middle East and North Africa. The Study had insufficient time to test alternative organizations on this type terrain; however, using BATTLE and the same methodology, another study group could easily test these organizations for Middle East Scenarios.

XIII. INTERPRETATION

a. Non Quantitative Factors (See ANNEX O [Non Quantitative Factors]).

(1) A tank battalion organized in a 3-3-3 configuration, lacked sustainability at each organizational level from the platoon to the battalion. Consequently, platoon cross attachment was impossible, any battle or maintenance losses had a dramatic impact on the viability of

of the platoon and company organizations, and the battalion was extremely sensitive to any small tactical error or adverse turn of events. In summary, 3-3-3 is organized too close to the margin of defeat for a battle against a Soviet tank regiment.

(2) The 3-4-3 battalion suffered inordinately high losses in battles requiring significant maneuvering because four platoons in a company proved unwieldy. The fourth tank platoon in each company overloaded the company commander, creating problems both with advantageous positioning of the fourth platoon and with extracting under pressure from company positions.

(3) The battalion organized in a 4-4-3 configuration had the same company level maneuver and positioning problems as 3-4-3; moreover, the extra tank in each platoon only exacerbated these problems. The greater number of tanks in 4-4-3, however, substantially increased this unit's sustainability.

(4) The 3-3-4 battalion suffered in its performance from the same lack of combat power at platoon and company level as the 3-3-3 battalion; however, the fourth company in this alternative gave the commander noticable flexibility not found in any three company battalions. With the addition of 4-3-4, the Study Group believed the four company alternative had continuing representation and therefore eliminated 3-3-4 from further study.

(5) The 4-3-3 battalion performed well, particularly at the platoon and company level. This alternative experienced difficulty only when it operated in a cross attached mode or had to fight the second echelon of the tank division's attack.

(6) The 5-3-3 battalion possessed excellent combat power at battalion level; however, the platoons proved relatively cumbersome in maneuver and slow in responsiveness. Most important, the fifth tank in the platoon was invariably poorly positioned, either exposed or in a masked position, a phenomenon familiar to the study participants in tactical exercises. The consensus of the members of the Study was that increased capabilities of modern tank weapons have made a five tank platoon too big for a platoon position. These shortcomings caused unnecessary losses at the platoon level and reduced responsiveness at the company level.

(7) The responsiveness and sustainability of the platoons and the additional flexibility of the fourth company were salient features that made 4-3-4 perform better than any other alternative. The 4-3-4 Battalion was unusually effective when the scenario required the units to conduct significant maneuver to defeat the Warsaw Pact force.

(8) Regardless of the alternative organization, the M-60A1 and the TOW weapons systems complemented each other to an exceptional degree. The tanks with their armor protection and rapid firing systems proved an excellent

system for holding the Soviet battalions at long range where the TOW's with impunity could kill large numbers of Pact vehicles. (See ANNEX R [Tactical Lessons Learned]).

b. Spillovers

(1) The following is a summary of the units and men that an Armored Division with six organic tank battalions would have to add to its Table of Organization and Equipment if it adopted any one of the five alternatives with no increase in its aggregate number of tanks (324):

Organization	BN in Div	TOW COMPANY	Additional BN HQs	Tank CO HQs
5-3-3	6	6 (4 Off/53 men @)	0	0
4-4-3	6	6 (4 Off/53 men @)	0	0
4-3-4	6	6 (4 Off/53 men @)	0	0
4-3-3	7	7 (4 Off/53 men @)	1	3
3-3-3	9	9 (4 Off/53 men @)	3	9

(2) Additional Manning: Alternatives 5-3-3 and 4-4-3 require the least additional manning. For a level of performance lower than that of 5-3-3, the 3-3-3 Battalion requires the greatest addition of personnel. Alternative 4-3-4 necessitates six additional tank company headquarters; however, this reorganization gives the Division a dramatic increase in performance at battalion level.

(3) Basing: If the Army adopts alternatives 5-3-3, 4-4-3, or 4-3-4, it will incur no basing problems above those that already exist. If, however, the Army adopted 4-3-3, each division would have to find billets for one additional battalion. The 3-3-3 alternative would require added space for three more battalions.

d. Incommensurables

(1) Leadership Lost

The ability of a battalion both to win on the battlefield and recover quickly from battle losses once it reaches a rear area is largely a function of leadership that survives, particularly at company and battalion level. Consequently, if the measure of cost was leadership lost, and the Study fixed effectiveness as in Criterion A, then the Study Group would have concluded that the performance of the various alternatives would rank as follows:

1. 4-3-4
2. 4-3-3
3. 4-4-3
4. 5-3-3
5. 3-3-3 (See ANNEX P [Leadership Lost])

(2) Combat Power Remaining

The possibility of interjecting a battalion immediately into a subsequent battle without any recovery time is materially a direct function of the percentage of the battalion's initial combat power that it retains from a battle. Moreover, the rapidity with which a battalion can recover from battle losses is also a direct function of the percentage of its combat power that the Division must replace. Therefore, this Study could have used the corollary to Criterion A and fixed effectiveness while measuring the amount of organic combat power remaining in the tank battalions at the end of the battles. Working with this corollary, the

Study Group would have rank ordered the performance of the various battalion organizations as follows:

1. 4-3-4
2. 4-3-3
3. 5-3-3
4. 3-3-3
5. 4-4-3 (See ANNEX Q [Combat Power Remaining])

e. Unknowns:

(1) This Study assumed near perfect fire distribution for both the U.S. and Soviets in the interest of conserving time. If fire distribution had been imperfect, the defender (the U.S. battalion) would have had much better fire distribution than the attacker (the Soviet force) for the following reasons:

(a) The defending force, starting from turret defilade, normally had time (one or two minutes) prior to initiating direct fire to observe the attacker and make initial fire distribution plans while the attacker had no time prior to initiation of fire to observe the defender.

(b) The entire attacking force was exposed to observation as was a large portion of each attacking vehicle.

(c) The defender selected the optimum time for the defense to open fire.

(d) The attacker had to maneuver and control maneuver as well as acquire targets and engage them.

(e) The attacker placed his entire company on the same radio frequency, effectively denying the platoons this means of directing fire.

(f) The Soviet procedure for control of fire is for the platoon leader to shoot at a target and for the other members of his platoon to also shoot at this same target until the target is destroyed. At best, this translates into only one-third of the coverage this Study afforded the Soviets.

(g) Only the obscuration represented by planned smoke concentrations delivered by FA or mortars entered into play. Smoke and dust from firings and detonations on the battlefield did not affect intervisibility, target acquisition, or fire distribution.

(2) The Study Group assumed perfect command and control for both the defending and attacking forces because of the difficulty of interjecting command and control mistakes (e.g., misunderstood radio transmissions, map reading errors, failure to respond, etc.). Command and control is always imperfect, and the fate of battles has turned on a single such mistake. In this Study, perfect command and control favored the defender for the following reasons:

(a) Soviet offensive tactics are exceptionally simple and once set in motion Soviet battalions seldom change their predetermined course of action (this is also a great weakness of Soviet tactics).

(b) U.S. active defense tactics are more complex and require close coordination of many diverse elements

in order to insure success. Consequently, U.S. tactics are more heavily dependent on excellent command and control.

(c) U.S. forces depend heavily on radio communications for command and control at the company and higher levels. Soviet jamming will hinder and complicate the use of radio for command and control.

(d) Much of the success of the active defense depends on the rapid response of U.S. platoon leaders and company commanders to intelligence flowing into the battalion headquarters. During the battle iterations, this Study gave neither side any information about the opposing forces until the information was obtained by visual contact. Therefore, neither side could react to moves of the other side until it could physically see what the other side was doing. Once visual contact had been made, however, the Study allowed the side with visual contact to gain perfect intelligence immediately on what it saw. This decidedly favored the U.S. battalion, because quick and accurate interpretation of intelligence is more critical to U.S. battalion active defense tactics than it is to Soviet regimental breakthrough tactics.

(3) This Study totally removed the human factors of fear and bravery from the battlefield, and yet these psychological factors would be critical on a battlefield of this size and ferocity.

(a) Studies by BG S.L.A. Marshall indicate that, at least in the U.S. Army, men organized into weapons

crews demonstrate much greater "participation in the battle" than do individual men with one weapon. Consequently, tank and TOW crews on a real battlefield might participate much closer to the degree of perfect participation used in this Study than would Dragon and LAW gunners.

(b) There is also no way to measure the "shock effect" and concomitant performance of U.S. forces on seeing for the first time massed Soviet tank formations moving at top speed toward them.

(c) Likewise, the attacking Soviets had a potential major problem because second echelon battalions and regiments had to pass through the carnage of over 100 recently destroyed vehicles before they could attack into the face of deadly accurate fire. Yet the Study allowed Soviet tanks to continue their advance as long as they had sufficient officers to provide leadership.

(d) Either force may have broken much earlier than the Study calculated based simply on a loss of will to endure the dangers they could see before them.

(e) The BATTLE Program does not account in its hit probabilities for suppression which is largely based upon fear. While this Study built in some suppression factors, it could not begin to approximate the real effects of fear on gunners attempting to acquire and engage targets. Therefore, both the defender and attacker fought through all iterations with perfect bravery.

(4) This Study imposed breakthrough tactics on the Soviets because the Study Group believed that breakthrough tactics pose the greatest threat to U.S. defenses in Central Europe.

(a) If the Soviets had attacked from the march column, the U.S. battalions should have uniformly performed better because Soviet regiments would have attacked in piecemeal formations (one or at most two battalions at a time).

(b) If the Soviets had attempted an "infiltration" type of attack one of two alternatives would have occurred:

(1) The attacking force would never have penetrated the Covering Force; or

(2) The attacking force, once it penetrated the Covering Force, would have followed avenue of approach that provided excellent cover and concealment. The divisions in Europe normally cover this type avenue of approach with mechanized infantry battalions (an organization which this Study did not examine).

XIV. CONCLUSIONS

a. Four tank platoons provided the optimum balance among sustainability, responsiveness, and ease of positioning.

b. Three platoons in a company did not overtax the company commanders' powers of command and control.

c. Four tank companies in the battalion made it viable in both an attached and cross attached mode against either a Tank or Motorized Rifle attack. The fourth company gave the battalion commander exceptional flexibility he did not possess with only three companies.

d. The tank and the TOW (long range anti-tank precision guided missiles) were exceptionally complementary weapons systems. Employed together, they made a deadly defensive team. The Tank Battalion must have an organic company of long range anti-tank precision guided missiles.

XV. RECOMMENDATION

This Study Group recommends that the U.S. Army reorganize two or more tank battalions with four tanks in a platoon, three platoons in a company, four companies in a battalion, and a TOW company for a year long garrison/field test.

ANNEX A

ASSUMPTIONS

ANNEX A (ASSUMPTIONS)

I. General Assumptions

- a. Neither side will employ toxic chemical munitions.
- b. Neither side will employ nuclear weapons.
- c. Close air support is not available to either side.
- d. Helicopter gunship support is not available to either side.
- e. Both sides possess smoke munitions.
 - (1) Once a smoke round impacts, smoke requires two minutes to build up to its full potential.
 - (2) The screen effect of smoke lasts for ten minutes after full build up.
 - (3) The 4.2in. mortar platoon and 122mm Howitzer Battery lay a smoke screen with one volley that is 300 meters by 150 meters.
 - (4) The 155mm Howitzer Battery and 152mm Howitzer Battery lay smoke screens with one volley that are 600 meters by 150 meters.
 - (5) The wind blows in the Hunfeld Area from the southwest at an average speed of 8 miles per hour.
- f. The BATTLE Program contains all engagement data (e.g., hit/kill probabilities, rates of fire, firing sequences times of flight etc.). These data, supplied by the Army Material Analysis Agency, are accepted as given and assumed representative of the battlefield.

g. There is no radio jamming for maneuver units.

h. The BATTLE Program jams on a random basis fire request nets.

i. Fire distribution is near perfect for both sides (i.e., the senior U.S. and Soviet player decide the fire distribution plan for every system on their respective sides).

j. Both U.S. and Soviet forces begin the battle at 100 percent operational ready rate.

k. If a firing vehicle is engaging at ranges greater than 1300 meters, in hull defilade, from a position previously not used (surprise shot), it may shoot both an initial and a burst on target (BOT) round before the target can return fire.

l. If a firing vehicle is engaging at ranges between 600 and 1300 meters, in hull defilade, from a position previously not used (surprise shot), it may shoot an initial round before the target can return fire.

m. If an engagement is initiated at less than 600 meters both vehicles may begin the engagement at the same time.

n. Dismounted teams (i.e., Dragon, LAW, RPG-7) receive one surprise shot without return fire regardless of range if they are firing from a new or previously undetected position.

o. Dismounted teams may be suppressed by either direct or indirect fire. When under suppression, a dismounted team will have to reload and reacquire targets at the start of every engagement.

- p. All firepower intervals are 30 seconds in duration.
- q. All maneuver intervals are 30 seconds in duration.
- r. To account for the time to get up to speed, all halted vehicles can move at only half speed for the first 30 seconds of movement.
- s. Neither side uses radars.
- t. Opposing forces have no intelligence of the other side until they can see their adversary.
- u. Once one force has seen its adversary the force with visual contact has perfect intelligence about the size and location of that organization but no intelligence about its scheme of maneuver.
- v. Vehicles knocked out on restricted routes (e.g., wooded trails or village streets) become obstacles. Other vehicles attempting to bypass knocked out vehicles must delay 30 seconds for each two knocked out vehicles it wants to bypass.
- w. Leadership and training are perfect, neither side will make any command and control errors (e.g., map reading errors, misunderstood radio communications, etc.).

II. United States Forces

- a. The Covering Force will strip away all Soviet reconnaissance elements prior to the Soviet breakthrough attack on the Main Battle Area (MBA).
- b. At the time of the attack, Battalion Scout Platoons will be screening between battalion battle positions and not

screening forward of the battalion battle position.

c. The U.S. force has six hours in which to prepare its battalion battle positions.

(1) This is sufficient time to prepare dug in positions on the battalion initial battle position.

(2) The Engineer Platoon has the munitions and can emplace six minefields (100 meters x 50 meters) or six obstacles or any combination of the two totaling six projects.

d. Once a VTR arrives at an immobilized vehicle it can hook up in 30 seconds.

e. A VTR can tow a disabled vehicle at one half the speed that the vehicle could normally move under its own power.

f. A VTR can tow two disabled tanks at one time.

g. If a vehicle carrying a commander is destroyed the commander is assumed dead.

h. Effective leadership at the Company level is the company commander. If the company commander is killed, the senior platoon leader becomes the effective leadership. The platoon leader does not need to relocate, and the company suffers no degradation in performance because a platoon leader is commanding.

i. Effective leadership at the platoon level is either the platoon leader or the platoon sergeant. If both the platoon leader and the platoon sergeant are killed, the company must either move a leader to the platoon or move

the platoon to a leader before the platoon can continue to participate in the battle.

j. The Engineer Platoon will lay mines and construct obstacles but can not participate in the battle as infantry.

k. The basic load of U.S. vehicles is as follows:

(1) M-60A1

40 - APDS

5 - HEAT

8 - HEP

2,000 - 50 Cal

10,000 - 7.62mm

(2) TOW

10 - TOW

1,000 - 50 Cal

(3) Dragon Team

6 - Dragons

(4) LAW Team

3 - LAWS

III. Warsaw Pact

a. All regiments lost their reconnaissance companies in the fight with the U.S. Covering Force.

b. The basic load of Soviet vehicles is as follows:

(1) T-62

14 - APFSDS

7 - HEAT

19 - HE

(2) BMP

5 - Sagger

10 - 73mm HEAT

c. All BMPs have Sagger mounted at the start of the battle.

d. All BMPs must be stationary during the entire period of a missile engagement.

e. A BMP in the assault can fire one Sagger every two minutes.

f. A dismounted Sagger Team can fire a missile every 30 seconds.

g. BMP must be stationary when firing the 73mm gun.

h. The BMP must fire the 73mm gun and Sagger from an exposed (rather than hull defilade) position.

i. BMPs have no night sight for either the Sagger or the 73mm gun.

j. Soviet forces can breach a U.S. obstacle in four minutes.

k. The BMP and T-62 can generate a smoke screen for 10 minutes.

l. When the Soviet tank regiment attacks, it has one Motorized Rifle Company attached to every Tank Battalion.

m. When the Motorized Rifle Battalion attacks, it has one 13 tank Tank Company attached to every Motorized Rifle Battalion.

n. Each tank platoon has one tank equipped with a mine plow.

o. Each tank battalion has one tank equipped with a mine roller.

p. The assault elements of both tank and motorized rifle regiments arrive at the U.S. MBA in a breakthrough formation (See Appendix 1 [Soviet Formations]).

q. A Soviet Tank or Motorized Rifle Regiment will not continue to advance once it has suffered 50% losses of organic systems (e.g., 50% of the T-62s in a Tank Regiment or 50% of the BMPs in a Motorized Rifle Regiment). Instead, the depleted regiment will hold in place, seek cover, continue to engage, and assist the passage of following regiments.

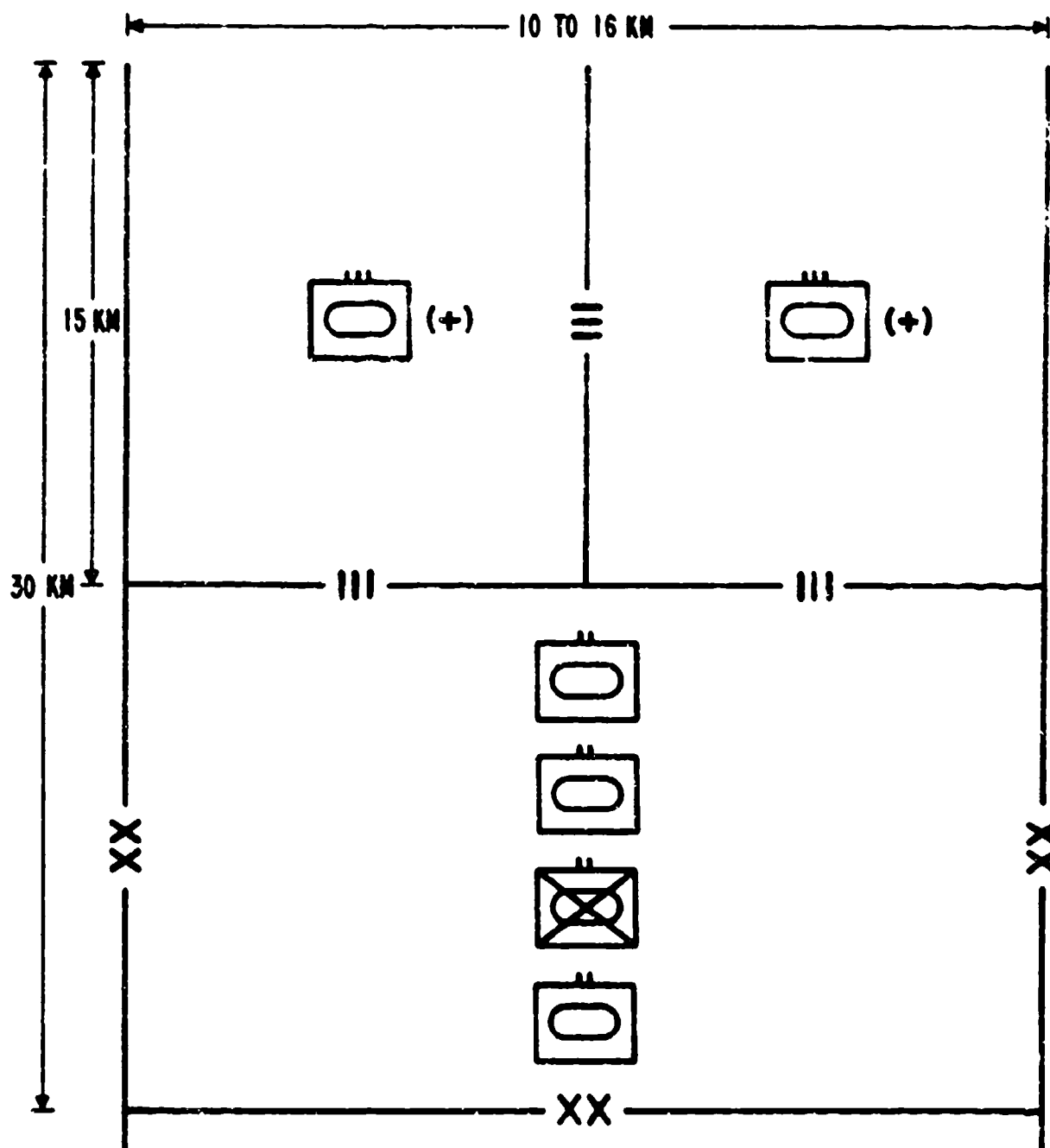
r. Soviet forces will attack at the maximum rate of movement permitted.

s. An attacking Soviet battalion when moving through a minefield will proceed 100 meters after the first mine is detected. Thereafter following vehicles will travel in the tracks of vehicles which previously breached the minefield. Once one battalion has breached a minefield all other battalions can follow the tracks of the previous battalion and traverse the minefield without casualties.

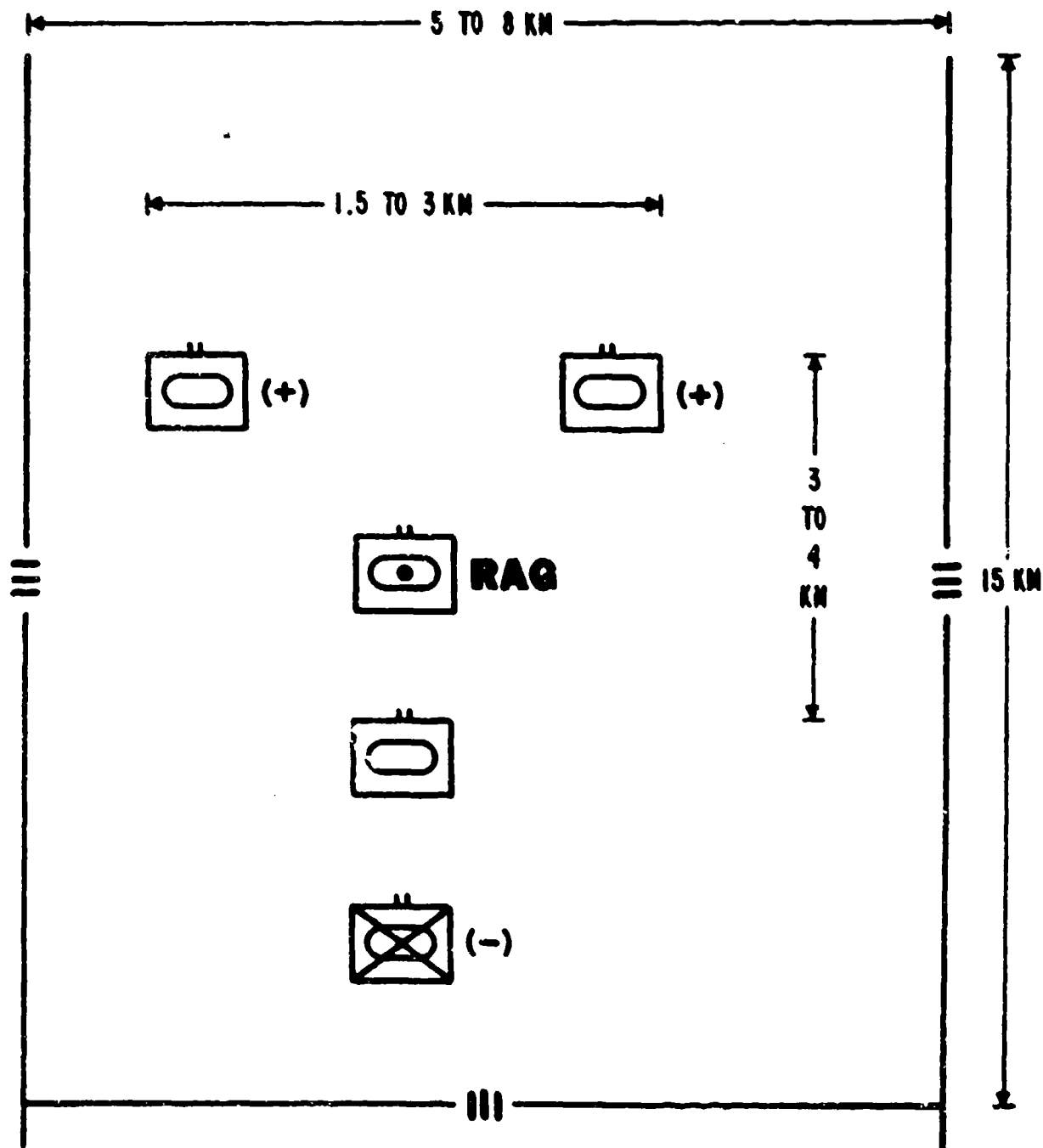
Appendix

Soviet Formations

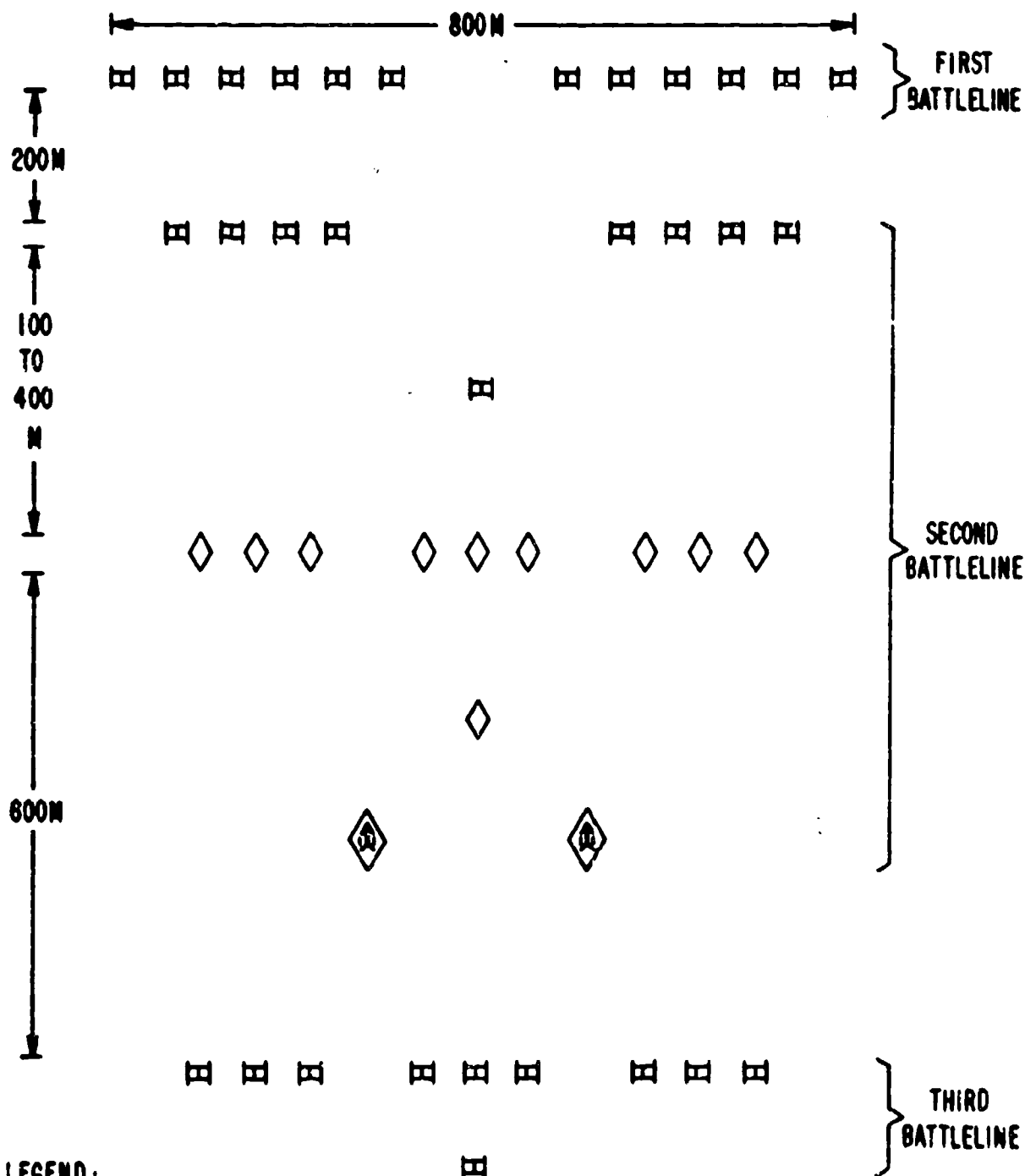
SOVIET TANK DIVISION BREAK THROUGH FORMATION



SOVIET TANK REGIMENT BREAK THROUGH FORMATION



SOVIET TANK BATTALION BATTLELINE FORMATION



LEGEND:

H TANK

◇ BMP (ARMORED PERSONNEL CARRIER)

◇ ZSU (ANTI-AIRCRAFT GUN)

ANNEX B

EXPLANATION OF METHODOLOGY

ANNEX B - EXPLANATION OF METHODOLOGY

I. INITIAL DEPLOYMENT

1. Each iteration began with the erecting of a screen between the main battle area and the area in which the Soviets deployed into their breakthrough formation. This allowed the U.S. player to deploy his troops without revealing their location to the Soviet player, and for the Soviet commander to select his avenues of advance and locations for his smoke missions without revealing his scheme of maneuver or having any intelligence beyond a map reconnaissance on which to base his smoke screen.

2. Once they removed the screen, the U.S. and Soviet players were committed to their initial deployment and axes of advance until some event (e.g. a visual sighting or receipt of direct fire) logically provided them with intelligence upon which to alter their previous plans.

II. INITIAL ENGAGEMENT RULES

1. The defender, starting in a position of defilade and able to move by covered routes, always opened the direct fire portion of the battle. In order to engage a target, the firing vehicle needed to have intervisibility with the target. The players determined intervisibility by stretching a string from the right front bumper of the firer to the right front bumper of the target. If the string did not touch any terrain feature between the two vehicles, then the firer had intervisibility with the target. (See Appendix 1 [Intervisibility])

2. In order to create the elements of local surprise that the defender normally possesses over his attacker, the Study Group used the following rules:

a. If the defender initiated direct fire at a range greater than 1300 meters from a defilade position from which no previous U.S. system had ever fired, the defender could fire an initial, and for tanks, a Burst On Target (BOT) round, before the target could return fire.

b. If all of the above conditions existed but the range was between 600 and 1300 meters, then the defender could only fire an initial round before the target could return fire.

c. If the range was less than 600 meters or any other conditions in a. above did not exist, then both sides could engage simultaneously.

III. DIRECT FIRE

1. Players input all direct fire information to the computer through IBM mark sense cards (see Appendix 2 (Computer Hardware)). On all direct fire input cards the players provide the computer with the following information:

- a. The type vehicle firing
- b. The type ammunition fired
- c. The vehicle number of the firer (all vehicles on the board had a unique number)
- d. Whether the firer was moving or stationary when firing

- e. The number of rounds being fired
- f. The range from the firer to the target
- g. The type vehicle that is the target
- h. The vehicle number of the target
- i. Whether the target is moving or stationary
- j. Whether the target is fully exposed or in hull defilade
- k. Whether the target is facing the firer or flank to the firer
- l. Whether the firer has acquired the target and has "a round in the chamber" ready to fire.

IV. FIREPOWER AND MOVEMENT INTERVAL

Training and Doctrine Command's System Analysis Agency (TRASANA) designed BATTLE so that the players could establish any interval of fire and maneuver they desire.

1. This study used 30 second intervals because that is the approximate time lapse required for a tank to engage a target with two rounds, back into total defilade, load a third round, and occupy an adjacent fighting position. This is also approximately the time a TOW crew needs to load a missile, fire it, track it to the target, and reload a second round.

2. The BATTLE program contains mean data on all engagement times (i.e. loading, firing, and time of flight) and the program will randomize these data to render a firing order among all Soviet and U.S. systems.

3. At the start of each firepower interval, both the Soviet and U.S. players input all vehicles they desire to fire during the 30 seconds of interval. The BATTLE Program will accept up to 80 of these cards during a single interval period.

4. As the computer runs through this 30 second interval, it will visually display the results of each engagement as it occurs (hit or miss, kill or no kill) and store the results. (See Appendix 3 [Computer Hardware in Operation]).

5. If a long range anti-tank precision guided missile team dies during the flight of a missile, the missile will always miss. If a vehicle is killed before it can fire, the computer will remove that vehicle from the computer's randomized firing order.

6. At the end of the 30 second firepower interval the program informs the players that they should take a 30 second maneuver interval. During this 30 seconds, the players can move their vehicles a scaled distance equal to the distance the vehicle could move during actual combat. Another 30 second fire power interval then follows and this rotation continues until the game's end.

V. INDIRECT FIRE

Players input indirect fire through IBM cards in a similar manner as they input direct fire.

1. For each indirect fire mission, a player must provide the following data:

(a) Whether the mission is for direct or general support battery or battalion.

(b) The board number of the battery (all batteries have a board number and a location stored within the program).

(c) The status of the forward observer (not trained, will adjust, will not adjust).

(d) Target type

(e) Status of target (in open, in woods, in town)

(f) Time by which last volley must land

(g) Ammo choice

(h) Number of volleys

(i) Radius of target area

2. Based upon randomized mean time to deliver the rounds, the computer will then tell the players during the sequence of firepower events when and where the volleys landed. Unlike the direct fire evaluation, however, indirect fire evaluation is not totally a Monte Carlo computer determined result. Indirect fire evaluation is only computer assisted and the player must input the following information before the computer can determine the results of the mission:

(a) Target type (on a mechanized battlefield what a commander originally shot at may have moved and a different target maneuvered under the indirect fire mission).

(b) Board numbers of all targets within the radius of lethality.

(c) Status of Target (open, wood or town)

(d) Azimuth and distance from the targets to aim point that landed (must be input a single target at a time).
(See Appendix 4 [Calculating the Location of Incoming Artillery])

(e) General Comments:

(1) All indirect fire missions called for Fire For Effect, and forward observers made no attempt to adjust fire. The short duration of each battle precluded the use of adjustment techniques; if forward observers had tried to adjust it was unlikely that fire for effect rounds would have arrived in time to affect the battle.

(2) Indirect fire systems never significantly influenced the outcome of any battle by killing a large number of vehicles and only rarely did they contribute to the measure of effectiveness.

(a) Lethality data within hit/kill probability data sets do not consider the shock effect of artillery or mortar rounds impacting on command and control, fire distribution, target acquisition, target/missile trackings, or intervisibility.

(b) Instead, players adjusted target acquisition and system firing rates during subsequent fire-power exchanges but could not make adjustments at the time of indirect fire evaluation unless the system in question was evaluated as killed. These limitations and adjustments were

present for Soviet and U.S. organizations, however, this did not favor one U.S. organization over another.

(3) Pre-planned fires were not used by either side. The use of pre-planned fires would have reduced response times and increased the amount of indirect fire on the battlefield. The indirect fire sub-routine present in BATTLE is cumbersome in this area.

(4) The numbers of the Study Group observed during the course of game play that FA and mortar-delivered smoke munitions had significant impact on the conduct of a battle and subsequently used their scarce indirect fire resources to take maximum advantage of that effect. Hence, no influences should be drawn from the quantities of FA, HE or ICM munitions expended by each side.

VI. SMOKE

The players of BATTLE must use both computer and manual operations to play the vital element of smoke.

1. A player desiring a smoke screen must input to the computer an indirect fire mission designating smoke.

2. After the computer has randomized the mean time to get the smoke rounds on the ground, the computer tells the players at the proper time during a firepower event where the smoke rounds have landed.

3. The players must then place a series of templates on the ground to show the build up of smoke over two minutes.

4. Then for the ten minutes following the complete build up of smoke, at each successive maneuver event the players must move the smoke at the speed and in the direction of the wind.

5. At the end of the twelve minutes, the players must lift the template from the terrain board.

6. All indirect fire smoke screens were assumed to be forty meters in height.

7. Soviet BMP's and T-62's can lay a smoke screen by injecting diesel into the exhaust manifold. This smoke screen was ten meters high, two hundred meters long, and spread into the direction to which the wind was blowing. These smoke screens were also laid on the terrain boards manually with a sponge template.

VII. MINEFIELDS

As the vehicles moved across the battlefield, some crossed minefields. The computer evaluates minefield crossings by the keyboard entry of the following data:

1. The minefield number (previously defined in density for the computer).
2. The number of rows of the minefield the target vehicle crossed.
3. The type vehicle crossing
4. The status of the vehicle
 - (a) Buttoned up moving fast (status used in the Study when the vehicle had to cross a minefield under direct fire).

(b) Buttoned up moving slow

(c) Hatches open moving fast (status used in the Study when the vehicle had to cross a minefield when not under direct fire).

(d) Hatches open moving slow.

VIII. PLAYER LEARNING CURVE

Unquestionably, both the Soviet and U.S. players become more adept with every iteration. Not only did they become better players they more importantly became familiar with how to use the particular terrain to greater advantage and how to use the organic and attached weapons systems to complement each other. In order to offset these advantages, the Study followed two procedures:

1. The Study Group varied the order in which the organizations ran through the different scenarios. For 4-3-4, this was possible only for Scenarios #5 and #6 (see X METHODOLOGY for an explanation). For Scenarios #1 through #4, 4-3-4 was the next to last organization to run the scenario. Because the study added 4-4-3 to the alternatives after the Study Group had run all other iterations, 4-4-3 was the last organization to be played in all scenarios.

2. The Study also alternated the battalion commanders playing the U.S. force. Consequently, no single commander played a particular organization in two successive scenarios.

IX. SUMMARY

The general Methodology, Game Rules, Key Factors, and Assumptions could not possibly cover all situations prior to their occurrence. During every iteration, the players had to decide in peculiar situations what methodology would approximate the reality of combat in Central Europe. (See Appendix 5 [Game in Progress]).

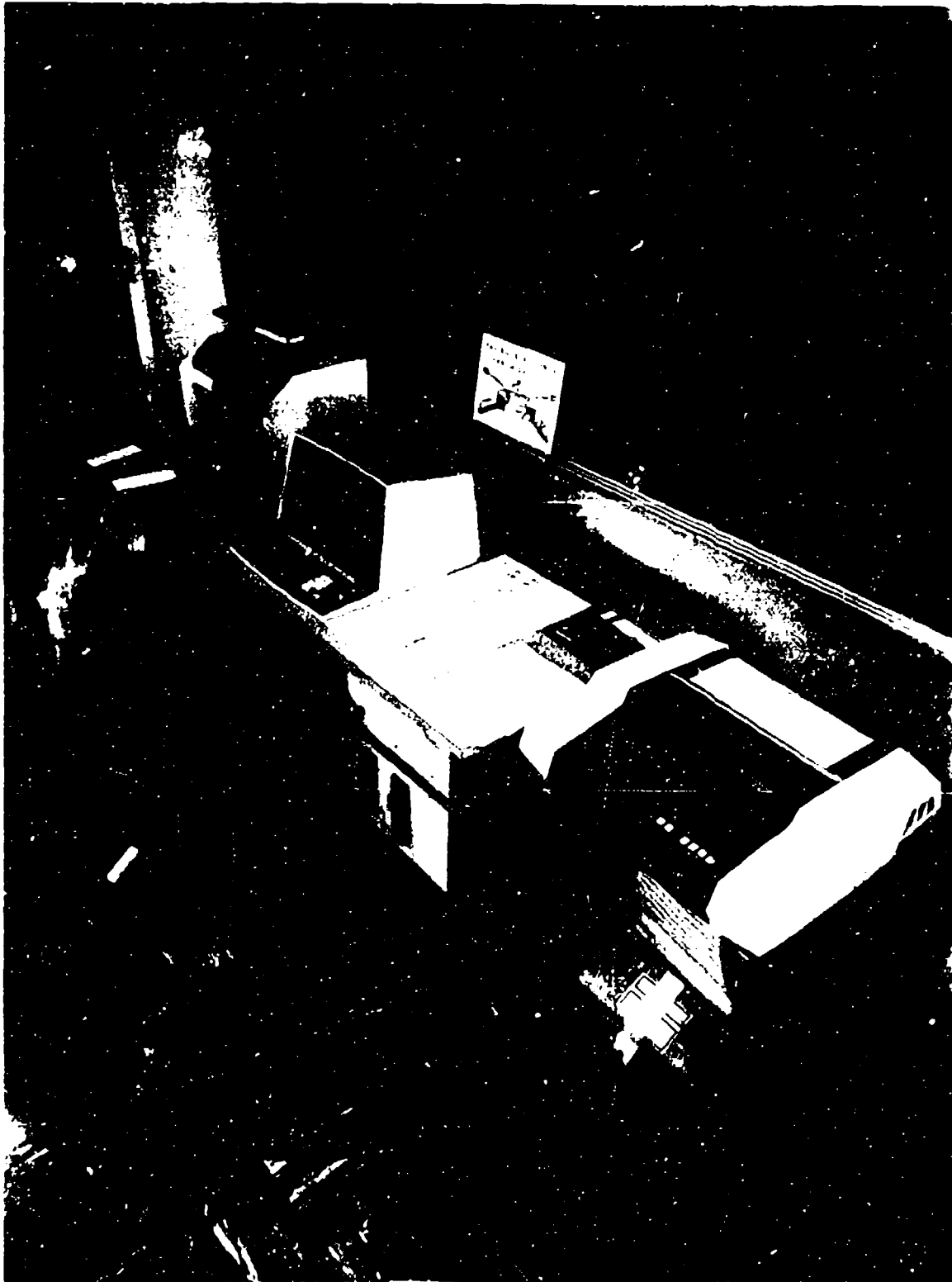
Appendices

1. Intervisibility
2. Computer Hardware
3. Computer Hardware in Operation
4. Calculating the Location of Incoming Artillery
5. Game in Progress

APPENDIX 1 to ANNEX B
INTERVISIBILITY



APPENDIX 2 to ANNEX B
COMPUTER HARDWARE



APPENDIX 3 to ANNEX B
COMPUTER HARDWARE IN OPERATION



APPENDIX 4 to ANNEX B
CALCULATING THE LOCATION OF INCOMING ARTILLERY



APPENDIX 5 TO ANNEX B
GAME IN PROGRESS



ANNEX C

COMBAT POWER INDEX

ANNEX C (Combat Power Index)

I. GENERAL: In order to aggregate and compare the relative Combat Power that differing systems and organizations contributed to the battle, the Study Group, developed a Combat Power Index (CPI), based upon the professional experience of the Study Group members. The Study assigned Combat Power Coefficients (CPC) for M60A1 Tanks, TOWs, Dragons, and LAWs. For Criterion B, the Study Group also assigned CPCs to T-62 Tanks and BMPs. These coefficients represent a measure of utility of a system considering its individual capabilities and limitations; values assigned were placed on a utility scale from 0.0 to 1.0.

II. U.S. DIRECT FIRE WEAPONS

a. In developing the CPC, the Study Group considered firepower, mobility, range of weapons, survivability, and the flexibility of employment of the system under all circumstances.

b. No correlation exists between a system's CPC and its performance in registering kills. Rather, CPCs take into consideration a system's total contribution to the battalion battle.

(1) LAW. A light anti-tank weapon with an exceptionally short range and limited utility, it nevertheless made a contribution in situations where infantry strongpoints

were employed, such as in villages and close terrain. In all cases, LAW was employed only by the attached infantry company. LAW's CPC = .1.

(2) Dragon. A short to medium range anti-tank guided missile (ATGM) with somewhat greater utility because of its greater range and lethality. Dragons were also employed by the infantry company. Dragons CPC = .2.

(3) TOW. Factors weighed in assignment of TOW's CPC included its excellent maximum effective range, lethality, and mobility, versus its slow rate of fire, limited night fighting capability, limited capability at ranges less than 700 meters, small basic load, and lack of survivability against direct fire. TOW's CPC = .4.

(4) M60A1. Its high rate of accurate aimed fire, excellent cross country mobility, armor protection, and flexibility of employment in open terrain, versus its high silhouette and limited night fighting capability were considered in assigning an M60A1's CPC, which equals .7,

III. DIRECT FIRE SOVIET WEAPONS

a. BMP. Excellent firepower (Sagger and 73mm smooth bore gun) to extended ranges, cross-country mobility, versatility (with its infantry squad), and armor protection, as opposed to slow rates of fire, small basic load of Sagger and 73mm HEAT, and limited night fighting capability was considered. This comparison with TOW CAP was inevitable,

and when all factors were balanced between the two systems caused a CPC equal to .4 to be assigned.

b. T-62. Similarly, comparison between M60A1 and T-62 tanks yielded the conclusion that they are roughly equivalent in capability. The Study Group, therefore, assigned a CPC equal to .7 to the T-62.

IV. ARTILLERY

a. Utilization of field artillery fires was not uniform throughout the iterations. Although U.S. and Soviet commanders employed much indirect fire in several battles, few losses were attributed to artillery (except Soviet BM 21 and U.S. 8 inch Howitzers). Suppression was considered according to the established game rules, as were the effects of smoke.

b. Since indirect fire made an infrequent contribution to the Study's measure of effectiveness - destroying Pact vehicles - a CPC seemed to be inappropriate. Implicitly, its contribution is included in the survivability of the U.S. force, the time delay(s) imposed on the attacking Soviets, and other output variables in ANNEX , Battle Results.

ANNEX D

BIOGRAPHICAL SKETCHES

ANNEX D (Biographical Sketches)

LTC Gerald P. Schurtz, Armor
DOR April 23, 1973

Assignment	Organization	Location
Troop XO	10th Cavalry	Korea
Troop Plt Ldr/XO	8th Cavalry	Ft. Lewis, WA
Regt S-2	11th ACR	RVN
Sqdn Cmdr	11th ACR	Germany
G-3 Plans	V Corps	Germany

LTC Frederick J. McConville, Field Artillery
DOR April 4, 1974

Assignment	Organization	Location
S-3 Officer	24th Inf Div	Germany
S-3 Officer	1st Cav Div	RVN
Asst G-2	1st Cav Div	RVN
Dist Sr Adv	MACV	RVN
Asst Sec	MACV	RVN
BN XO	1st Cav Div	Ft. Hood, TX
Div Arty S-3	1st Cav Div	Ft. Hood, TX
BN CO	1st Cav Div	Ft. Hood, TX

MAJ Henry J. Lowe, Armor
DOR October 10, 1975

Assignment	Organization	Location
Plt Ldr	12th Cavalry	Germany
Troop CO	12th Cavalry	Germany
Sqdn S-3	12th Cavalry	Germany
Regt S-3 Air	11th ACR	RVN
Asst J-3 Opns	III MAF	RVN
Troop CO	11th ACR	Germany
Sqdn S-3	11th ACR	Germany
Sqdn XO	11th ACR	Germany

MAJ James J. Steele, Armor
DOR June 8, 1976

Assignment	Organization	Location
Plt Ldr	13th Armor	Ft. Hood, TX
CO XO	13th Armor	Ft. Hood, TX
Plt Ldr	11th ACR	RVN
Troop CO	11th ACR	RVN
S-3 Air	11th ACR	RVN
Regt S-1	11th ACR	Germany
Troop CO	11th ACR	Germany
Sqdn S-3	11th ACR	Germany
Sqdn XO	11th ACR	Germany

ANNEXES E - L

ARE CONTAINED IN VOLUME II

ANNEX M

ANALYSIS OF VARIANCE

ANNEX M (Analysis of Variance)

I. GENERAL. Analysis of Variance (AOV) was conducted to determine if variation in results of battles could be attributed to a change in key factors (variables), or if variation resulted from chance alone.

II. A matrix of results was constructed, with organizations' results in the columns and the scenarios' results in rows. Then an AOV was conducted on the means of battles by scenario and by organization for; (1) Normalized Combat Power Lost (the MOC), shown in Appendix 1, (2) Combat Power Lost (Row), in Appendix 2, and (3) M60A1 Tanks Lost (Row), in Appendix 3. Data points for these Appendices are derived in Appendix 4-9, this ANNEX.

III. F_1 is the F-Statistic for scenarios (horizontal), while F_2 is for organizations (vertical). Both were analyzed at the 95% confidence level ($F_{.05}$).

IV. In all three treatments, the F-Statistic for scenarios means (F_1) exceeded $F_{.05}$, allowing rejection of the null hypothesis. Specifically variation in the scenarios means (\bar{x}) can be attributed to something other than chance, which could be anticipated since variation of key factors in each scenario was designed to present the alternative organizations with different situations.

V. However, in all three treatments the F-Statistic for organization means (F_2) was less than $F_{.05}$; hence, the null hypothesis cannot be rejected and, in the absence of further

testing, variation in organization, means could be attributed to chance.

VI. This outcome could not be anticipated by inspection of the data. There is considerable variation in organization means; heuristically, one would expect this variation to be attributable to organizational difference. However, the wide spread of standard deviation(s) for the organization may explain why the F-Statistic did not lie outside the limit. In any case, because the F-Statistic for organization means was not statistically significant, further analysis was conducted.

VII. Three measurements of Loss Exchange Rate (LER) were extracted from ANNEX L, (Loss Exchange Rate) arrayed in the same manner as above, and an AOV was conducted. The general formula for LER is:

$$\text{LER} = \frac{\text{Soviet Vehicles Destroyed (By)}}{\text{US Vehicles (Lost)}}$$

Thus, Appendix 10 is the LER for the total U.S. force, Appendix 11 is the LER for M60A1 and TOW, and Appendix 12 is the LER for M60A1.

VIII. In all three treatments, the F-Statistic for scenario means (F_1) and organization means (F_2) behaved the same. F_2 exceeded $F_{.05}$, allowing rejection of the null hypothesis that all variation between organization means may be attributable to chance. Thus, differences in organization means (x) is instructive, since means falling outside the

population must have a reason, ostensibly a demonstrable difference in target-servicing capability. By inspection, in all three treatments the means for 4-3-4 (7.24, 8.8, and 11.48, respectively) are obviously outside the distribution, on the positive side. Intuitively, 4-3-4 must provide a significantly greater target servicing capability than the other organizations.

IX. Similarly, the F-Statistic for scenario means (F_1) was less than its $F_{.05}$, which did not allow rejection of H_0 in this case. Specifically, variation in means between scenarios can be attributed only to chance. Intuitively, this result can be supported, as it is expected that variations in LER between scenarios will depend on the nature of key factors - visibility, terrain, rate of movement, and threat - in each scenario. For example, LER for a battle at 1000 meters visibility should be quite different than one at 3000 meters which is borne out by the data. Thus, a rank order of organizations (excluding 3-3-4 and 3-4-3) is as follows:

(1) ORGAN	(2) LER (TOTAL)	(3) ORGAN	(4) CP LOST(NORM)
4-3-4	7.24	4-3-4	12.10
5-3-3	3.89	4-3-3	23.18
4-3-3	3.38	5-3-3	30.65
4-4-3	3.31	3-3-3	33.92
3-3-3	2.76	4-4-3	35.32

Comparison of Columns (1) and (3) reveal 4-3-4 prevails under both measurements, by a substantial margin (@ 100%), whereas, the remaining organizations experience minor shifts.

Organizations with greater numbers of tanks displace smaller organizations, Column (1), possibly a reflection of greater target servicing capability.

Appendix 1 (Analysis of Variance for Percentage of Normalized Combat Power Lost)
to ANNEX M (Analysis of Variance Computation)

ANALYSIS OF VARIANCE

PERCENTAGE OF NORMALIZED COMBAT POWER LOST

SCENARIO	ORGANIZATION										N	\bar{X}	S^2	S
	3-3-3	4-3-3	4-4-3	4-3-4	5-3-3	3-3-4	3-4-3							
1	28.1	16.9	36.4	3.0	41.3	32.5	10.2				7	24.06	203.99	14.28
2	47.4	45.4	63.0	21.2	68.2 ^a	50.4	74.9				7	52.93	319.62	17.88
3	13.4	11.7	4.5	3.2	7.1	5.6	-				6	7.58	16.73	4.09
4	45.0	47.6 ^a	31.8	21.4	37.4	20.8	-				6	34.00	137.07	11.45
5	27.3	10.6	29.0	13.6	18.2	-	-				5	19.74	66.53	8.16
6	42.3	6.9	47.2	10.2	11.7	-	-				5	23.66	376.67	19.41
N	6	6	6	6	6	4	2				$F_1 = 8.08$			
\bar{X}	33.92	23.18	35.32	12.10	30.65	27.33	42.55				$\frac{DF}{DF} \frac{5}{30}$			
S^2	174.69	356.92	382.14	67.44	527.54	351.93	2093.05				Ho: $\bar{x}_1 = \bar{x}_2 = \dots$			
S	13.22	18.36	19.55	8.21	22.97	18.92	45.75				$P_{.05} \text{ for } DF \frac{5}{30} = 2.53$			

$F_2 = 1.21$

$\frac{DF}{DF} \frac{6}{29}$

Ho: $\bar{x}_1 = \bar{x}_2 = \dots$

$P_{.05} \text{ for } DF \frac{6}{29} = 2.44$

$F_2 = 1.21 < 2.44$ Do not reject Ho

NOTE: a. Soviet effectiveness degraded by 46% only (100 T62s). U.S. position untenable at that point. Battle terminated in view of likelihood of defeat.

$F_1 = 8.08 > 2.53$ reject Ho

Appendix 2 (Analysis of Variance for Percentage of Combat Power Lost (RAW)) to ANNEX H
(Analysis of Variance Computation)

ANALYSIS OF VARIANCE

PERCENTAGE OF COMBAT POWER LOST (RAW)

SCENARIO	ORGANIZATION										N	\bar{X}	$\sum S^2$	
	3-3-3	4-3-3	4-4-3	4-3-4	5-3-3	3-3-4	3-4-3						S	S
1	38.7	19.5	36.9	3.0	41.3	36.3	11.8				7	26.79	231.47	15.21
2	65.2	52.6	64.0	21.2	68.2	56.4	86.7				7	59.19	398.61	19.97
3	18.4	13.5	4.6	3.2	7.1	6.3					6	8.85	34.48	5.87
4	61.9	55.1	32.3	21.4	37.4	23.2					6	38.55	277.85	16.67
5	37.5	12.2	29.5	13.6	18.2						5	22.2	119.34	10.92
6	56.0	8.6	48.2	9.4	11.7						5	26.78	543.15	23.31
N	6	6	6	6	6	4	2							
\bar{X}	46.28	26.92	35.92	11.97	30.63	30.55	43.25							
$\sum S^2$	321.65	448.21	395.1	68.15	527.11	447.79	2805.0							
S	17.93	21.17	19.88	8.26	22.96	21.16	52.96							

$F_2 = 1.67$
 $\frac{DF}{DF} \frac{6}{29}$
 $F_{.05} \text{ for } DF \frac{6}{29} = 2.44$
 $F_2 = 1.67 < 2.44$: do not reject H_0

$F_1 = 7.09$
 $\frac{DF}{DF} \frac{5}{30}$
 $H_0: \bar{x}_1 = \bar{x}_2 = \dots$
 $F_{.05} \text{ for } DF \frac{5}{30} = 2.53$
 $F_1 = 7.09 > 2.53$: Reject H_0

Appendix 3 (Analysis of Variance for Percentage of Tanks Lost (RAW)) to ANNEX M
(Analysis of Variance Computation)

ANALYSIS OF VARIANCE

PERCENTAGE OF TANKS LOST (RAW)

SCENARIO	ORGANIZATION										N	\bar{X}	$\sum S^2$	
	3-3-3	4-3-3	4-4-3	4-3-4	5-3-3	3-3-4	3-4-3						S	S
1	50.0	22.2	41.5	0.0	46.3	38.3	11.1				7	29.91	364.1	19.08
2	69.4	55.6	69.8	16.7	90.7	53.2	93.3				7	64.1	676.4	26.01
3	16.7	11.1	5.6	0.0	5.6	0.0					6	6.5	42.26	6.50
4	63.9	55.6	39.6	22.2	46.3	21.3					6	41.48	301.55	17.37
5	50.0	15.6	35.8	16.7	22.2						5	28.06	214.98	14.66
6	72.0	8.3	55.6	12.2	8.1						5	31.24	919.75	30.33
N	6	6	6	6	6	4	2				$F_1 = 5.54$			
\bar{X}	53.67	28.07	41.32	11.3	36.53	28.2	52.2				$\frac{DF\ 5}{DF\ 30}$			
S^2	416.36	476.92	464.88	86.66	10.19	523.29	33.78				Ho: $\bar{X}_1 = \bar{X}_2 = \dots$			
S	20.40	21.84	21.56	9.31	31.92	22.88	58.12				$P_{.05} \text{ for } \frac{DF\ 5}{DF\ 30} = 2.53$			

$F_2 = 1.89$

$\frac{DF\ 6}{DF\ 29}$

Ho: $\bar{X}_1 = \bar{X}_2 = \dots$

$P_{.05} \text{ for } \frac{DF\ 6}{DF\ 29} = 2.44$

$F_2 = 1.89 < 2.44$: do not reject Ho

$F_1 = 5.54 > 2.53$: Reject Ho

Appendix 4 (Scenario #1) to ANNEX M (Analysis of Variance
Computation)

No Fixed Effectiveness - Measured Costs

No Effectiveness = 50% of Soviet Organic Vehicles Destroyed

SCENARIO: 1

ENEMY: 1 Tank Regt (93 T-62)+1 Mech Bn (31 BMP)

VISIBILITY: 2200 meters

<u>TIME (SEC.):</u>	419	130	483	97	227	452	338
<u>ORGANIZATION</u>	3-3-3	4-3-3	4-4-3	4-3-4	5-3-3	3-3-4	3-4-3
¹ <u>CP LOST</u> <u>(NORMALIZED):</u>	28.1	16.9	35.4	3.0	41.3	32.5	10.2
² <u>CP LOST:</u>	38.7	19.5	36.9	3.0	41.3	36.3	11.8
³ <u>M-60A1 LOST</u> <u>(NORMALIZED):</u>	33.3	18.5	40.7	0.0	46.3	33.3	9.3
⁴ <u>M-60A1 LOST:</u>	50.0	22.2	41.5	0.0	46.3	38.3	11.1

NOTE: All figures represent the percentage of combat power or M-60A1's lost by a battalion during the course of a battle.

1. Combat Power (CP) Lost (Normalized) (%) = $.7(\#M-60A1 \text{ Lost}) + .4(\#TOW \text{ Lost}) + .2(\#Dragons \text{ Lost}) + .1(\#LAWS \text{ Lost}) \div CP_{5-3-3} = (46.2) \text{ utils}$
2. Combat Power (CP) Lost (%) = $.7(\#M60A1s \text{ Lost}) + .4(\#TOWs \text{ Lost}) + .2(\#Dragons \text{ Lost}) + .1(\#LAWS \text{ Lost}) \div CP_{ORG}$
3. M-60A1 Lost (Normalized) (%) = $\frac{\# M-60A1 \text{ Lost}}{\# M-60A1 \text{ in } 5-3-3} (=54)$
4. M-60A1 Lost (%) = $\frac{\# M-60A1 \text{ Lost}}{\# M-60A1 \text{ in } ORG \text{ (initial)}}$

Appendix 5 (Scenario #2) to ANNEX M (Analysis of Variance Computation)

No Fixed Effectiveness - Measured Costs

No Effectiveness = 50% of Soviet Organic Vehicles Destroyed

SCENARIO: 2

ENEMY: 2 Tank Regt(186 T-62)+1 Div Tank Bn(31 T-62)+2 Mech Bn (62 BMP)

VISIBILITY: 2200 meters

<u>TIME (SEC.):</u>	6928	6088	6032	6371	2653	6104	4958
<u>ORGANIZATION</u>	3-3-3	4-3-3	4-4-3	4-3-4	5-3-3	3-3-4	3-4-3
¹ <u>CP LOST (NORMALIZED):</u>	47.4	45.4	63.0	21.2	68.2	50.4	74.9
² <u>CP LOST:</u>	65.2	52.6	64.0	21.2	68.2	56.4	86.7
³ <u>M-60A1 LOST (NORMALIZED):</u>	46.3	46.3	68.5	16.7	90.7	46.3	77.7
⁴ <u>M-60A1 LOST:</u>	69.4	55.6	69.8	16.7	90.7	53.2	93.3

NOTE: All figures represent the percentage of combat power or M-60A1's lost by a battalion during the course of a battle.

1. Combat Power (CP) Lost (Normalized) (%) = $.7(\#M-60A1 \text{ Lost}) + .4(\#TOW \text{ Lost}) + .2(\#Dragons \text{ Lost}) + .1(\#LAWS \text{ Lost}) \div CP_{5-3-3}$ = (46.2) utils
2. Combat Power (CP) Lost (%) = $.7(\#M60A1s \text{ Lost}) + .4(\#TOWs \text{ Lost}) + .2(\#Dragons \text{ Lost}) + .1(\#LAWS \text{ Lost}) \div CP_{ORG}$
3. M-60A1 Lost (Normalized) (%) = $\frac{\# M-60A1 \text{ Lost}}{\# M-60A1 \text{ in } 5-3-3 (=54)}$
4. M-60A1 Lost (%) = $\frac{\# M-60A1 \text{ Lost}}{\# M-60A1 \text{ in } ORG \text{ (initial)}}$

Appendix 6 (Scenario #3) to ANNEX M (Analysis of Variance Computation)

No Fixed Effectiveness - Measured Costs

No Effectiveness = 50% of Soviet Organic Vehicles Destroyed

SCENARIO: 3

ENEMY: 1 Tank Regt (93 T-62)+1 Mech BN (31 BMP)

VISIBILITY: 3000 meters

<u>TIME (SEC.):</u>	158	241	182	184	183	392
<u>ORGANIZATION</u>	3-3-3	4-3-3	4-4-3	4-3-4	5-3-3	3-3-4
¹ <u>CP LOST (NORMALIZED):</u>	13.4	11.7	4.5	3.2	7.1	5.6
² <u>CP LOST:</u>	18.4	13.5	4.6	3.2	7.1	6.3
³ <u>M-60A1 LOST (NORMALIZED):</u>	11.1	9.3	5.5	0	5.6	0
⁴ <u>M-60A1 LOST:</u>	16.7	11.1	5.6	0	5.6	0

NOTE: All figures represent the percentage of combat power or M-60A1's lost by a battalion during the course of a battle.

1. Combat Power (CP) Lost (Normalized) (%) = $.7(\#M-60A1 \text{ Lost}) + .4(\#TOW \text{ Lost}) + .2(\#Dragons \text{ Lost}) + .1(\#LAWS \text{ Lost}) \div CP_{5-3-3} = (46.2) \text{ utils}$
2. Combat Power (CP) Lost (%) = $.7(\#M60A1s \text{ Lost}) + .4(\#TOWs \text{ Lost}) + .2(\#Dragons \text{ Lost}) + .1(\#LAWS \text{ Lost}) \div CP_{ORG}$
3. M-60A1 Lost (Normalized) (%) = $\frac{\# M-60A1 \text{ Lost}}{\# M-60A1 \text{ in } 5-3-3 (=54)}$
4. M-60A1 Lost (%) = $\frac{\# M-60A1 \text{ Lost}}{\# M-60A1 \text{ in } ORG \text{ (initial)}}$

Appendix 7 (Scenario 4) to ANNEX M (Analysis of Variance Computation)

No Fixed Effectiveness - Measured Costs

No Effectiveness = 50% of Soviet Organic Vehicles Destroyed

SCENARIO: 4

ENEMY: 2 Tank Regt(186 T-62)+Div Tk Bn(31 T-62)+2 Mech Bn (62 BMP)

VISIBILITY: 3000 meters

TIME (SEC.):	4440	6446	2532	4374	3373	3302
ORGANIZATION	3-3-3	4-3-3	4-4-3	4-3-4	5-3-3	3-3-4
¹ CP LOST (NORMALIZED):	45.0	47.6	31.8	21.4	37.4	20.8
² CP LOST:	61.9	55.1	32.3	21.4	37.4	23.2
³ M-60A1 LOST (NORMALIZED):	42.6	46.3	38.9	22.2	46.3	18.5
⁴ M-60A1 LOST:	63.9	55.6	39.6	22.2	46.3	21.3

NOTE: All figures represent the percentage of combat power or M-60A1's lost by a battalion during the course of a battle.

1. Combat Power (CP) Lost (Normalized) (%) = $.7(\#M-60A1 \text{ Lost}) + .4(\#TOW \text{ Lost}) + .2(\#Dragons \text{ Lost}) + .1(\#LAWS \text{ Lost}) \div CP_{5-3-3}$ (46.2) utils
2. Combat Power (CP) Lost (%) = $.7(\#M60A1s \text{ Lost}) + .4(\#TOWs \text{ Lost}) + .2(\#Dragons \text{ Lost}) + .1(\#LAWS \text{ Lost}) \div CP_{ORG}$
3. M-60A1 Lost (Normalized) (%) = $\frac{\# M-60A1 \text{ Lost}}{\# M-60A1 \text{ in } 5-3-3} (=54)$
4. M-60A1 Lost (%) = $\frac{\# M-60A1 \text{ Lost}}{\# M-60A1 \text{ in } ORG \text{ (initial)}}$

Appendix 8 (Scenario #5) to ANNEX M (Analysis of Variance
Computation)

No Fixed Effectiveness - Measured Costs

No Effectiveness = 50% of Soviet Organic Vehicles Destroyed

SCENARIO: 5

ENEMY: 1 Tank Regt (93 T-62)+1 Mech BN (31 BMP)

VISIBILITY: 1000 meters

<u>TIME (SEC.):</u>	94	102	270	92	95
<u>ORGANIZATION</u>	3-3-3	4-3-3	4-4-3	4-3-4	5-3-3
¹ <u>CP LOST</u> <u>(NORMALIZED):</u>	27.3	10.6	29.0	13.6	18.2
² <u>CP LOST:</u>	37.5	12.2	29.5	13.6	18.2
³ <u>M-60A1 LOST</u> <u>(NORMALIZED):</u>	33.3	13.0	35.2	16.7	22.2
⁴ <u>M-60A1 LOST:</u>	50.0	15.6	35.8	16.7	22.2

NOTE: All figures represent the percentage of combat power or M-60A1's lost by a battalion during the course of a battle.

1. Combat Power (CP) Lost (Normalized) (%) = $.7(\#M-60A1 \text{ Lost}) + .4(\#TOW \text{ Lost}) + .2(\#Dragons \text{ Lost}) + .1(\#LAWS \text{ Lost})$: $CP_{5-3-3} = (46.2) \text{ utils}$
2. Combat Power (CP) Lost (%) = $.7(\#M60A1s \text{ Lost}) + .4(\#TOWs \text{ Lost}) + .2(\#Dragons \text{ Lost}) + .1(\#LAWS \text{ Lost})$: CP_{ORG}
3. M-60A1 Lost (Normalized) (%) = $\frac{\# M-60A1 \text{ Lost}}{\# M-60A1 \text{ in } 5-3-3 (=54)}$
4. M-60A1 Lost (%) = $\frac{\# M-60A1 \text{ Lost}}{\# M-60A1 \text{ in } ORG \text{ (initial)}}$

Appendix 9 (Scenario #6) to ANNEX M (Analysis of Variance Computation)

No Fixed Effectiveness - Measured Costs

No Effectiveness = 50% of Soviet Organic Vehicles Destroyed

SCENARIO: 6*

ENEMY: 1 Mech Regt (93 BMP) + Div Tank Bn (40 T-62)

VISIBILITY: 2200 meters

<u>TIME (SEC.):</u>	186	217	186	144	212
<u>ORGANIZATION</u>	3-3-3	4-3-3	4-4-3	4-3-4	5-3-3
¹ <u>CP LOST (NORMALIZED):</u>	42.3	6.9	47.2	10.2	11.7
² <u>CP LOST:</u>	56.0	8.6	48.2	9.4	11.7
³ <u>M-60A1 LOST (NORMALIZED):</u>	33.3	5.4	54.1	13.5	8.1
⁴ <u>M-60A1 LOST:</u>	72.0	8.3	55.6	12.2	8.1

NOTE: All figures represent the percentage of combat power or M-60A1's lost by a battalion during the course of a battle.

1. Combat Power (CP) Lost (Normalized) (%) = $.7(\#M-60A1 \text{ Lost}) + .4(\#TOW \text{ Lost}) + .2(\#Dragons \text{ Lost}) + .1(\#LAWS \text{ Lost}) \div CP_{5-3-3} = (46.2) \text{ utils}$
2. Combat Power (CP) Lost (%) = $.7(\#M60A1s \text{ Lost}) + .4(\#TOWs \text{ Lost}) + .2(\#Dragons \text{ Lost}) + .1(\#LAWS \text{ Lost}) \div CP_{ORG}$
3. M-60A1 Lost (Normalized) (%) = $\frac{\# M-60A1 \text{ Lost}}{\# M-60A1 \text{ in } 5-3-3 (=54)}$
4. M-60A1 Lost (%) = $\frac{\# M-60A1 \text{ Lost}}{\# M-60A1 \text{ in } ORG \text{ (initial)}}$

* CP_{ORG} for Scenario 6 is different; one tank company detached.

ANALYSIS OF VARIANCE

LER = SOVIET VEHICLES DESTROYED (BY)
M60A1+TOW+DRAGON+LAW) LOST

SCENARIO	ORGANIZATION										N	\bar{X}	\sum^2	S
	3-3-3	4-3-3	4-4-3	4-3-4	5-3-3	3-3-4	3-4-3							
1	2.52	3.09	1.58	6.38	1.97	2.00	4.58				7	3.16	3.01	1.73
2	2.67	2.70	1.71	3.38	2.54	2.56	1.92				7	2.50	.30	.55
3	2.79	3.67	8.29	9.00	6.38	2.80	-				6	5.49	7.76	2.79
4	3.19	2.70	3.37	4.45	3.90	3.24	-				6	3.48	.38	.61
5	3.05	4.47	2.29	6.42	4.00	-	-				5	4.05	2.47	1.57
6	2.33	3.64	2.60	13.83	4.53	-	-				5	5.39	23.05	4.80
N	6	6	6	6	6	4	2				$F_1 = 1.66$			
\bar{X}	2.76	3.38	3.31	7.24	3.89	2.65	3.26				$\frac{DF}{DF} \frac{5}{30}$			
\sum^2	.10	.47	6.38	14.12	2.43	.27	3.51				Null Hypothesis: $\bar{X}_1 = \bar{X}_2 = \dots$			
S	.32	.69	2.53	3.76	1.56	.52	1.87				$F_{.05} \text{ for } \frac{DF}{DF} \frac{5}{30} = 2.53$			

 $F_2 = 3.40$ $DF \frac{5}{30}$ $DF \frac{5}{30}$ Ho: $\bar{X}_1 = \bar{X}_2 = \dots$ $\bar{X}_1 \bar{X}_2$ $F_{.05} \text{ for } \frac{DF}{DF} \frac{5}{30} =$ $F_2 = 3.40 > 2.53; \text{ reject Ho}$

$F_1 = 1.66 < 2.53; \text{ do not reject Ho}$

Appendix 11 (Analysis of Variance, LER [M60A1 + TOW]) to ANNEX M (Analysis of Variance)

ANALYSIS OF VARIANCE

LER = SOVIET VEHICLES DESTROYED (BY)
(M60A1 + TOW) LOST

SCENARIO	ORGANIZATION										N	\bar{X}	2	S	S
	3-3-3	4-3-3	4-4-3	4-3-4	5-3-3	3-3-4	3-4-3								
1	1.86	2.52	1.78	13.67	1.83	2.14	7.14				7	4.42	20.33	4.51	
2	3.10	2.69	1.97	3.69	2.22	2.59	1.92				7	2.60	.41	.64	
3	2.24	4.08	6.86	15.62	6.38	4.00	-				6	6.53	22.71	4.77	
4	2.97	3.74	2.74	4.25	3.34	3.78	-				6	3.47	.32	.56	
5	2.65	4.24	2.00	6.08	3.76	-	-				5	3.7	2.49	1.58	
6	2.57	4.13	1.90	9.50	3.86	-	-				5	4.39	8.99	2.99	
N	6	6	6	6	6	4	2								
\bar{X}	2.57	3.57	2.88	8.80	3.57	3.13	4.53								
S	.21	.59	3.93	24.99	2.58	.82	13.62								
S	.46	.77	1.98	4.99	1.61	.91	3.69								

$F_2 = 4.44$

DF 6
DF 29

Null Hypothesis: $- = - = \dots$

$x_1 \ x_2$

$F_{.05}$ for DF 6 =
DF 29

$F_2 = 4.44 > 2.53$; reject H_0

$F_1 = 1.16$

DF 5

DF 30

Null Hypothesis:

$- = - = \dots$

$x_1 \ x_2$

$F_{.05}$ for DF 5 = 2.53
DF 30

$F_1 = 1.16 < 2.53$; do not
reject
 H_0

ANALYSIS OF VARIANCE

LER = SOVIET VEHICLES DESTROYED (BY)
M60A1 LOST

SCENARIO	ORGANIZATION						\bar{X}		S ²		
	3-3-3	4-3-3	4-4-3	4-3-4	5-3-3	3-3-4	3-4-3	N	X	S	S
1	1.15	1.61	1.33	25.0*	1.27	1.89	4.33	7	5.23	77.24	8.79
2	1.80	1.86	1.49	3.15	1.63	2.09	1.48	7	1.93	.34	.58
3	1.56	2.11	5.58	26.0**	7.0	2.00	-	6	7.38	88.14	9.39
4	2.35	1.52	2.43	3.24	2.35	2.39	-	6	2.38	.29	.54
5	1.60	3.18	1.63	4.83	3.35	-	-	5	2.92	1.83	1.36
6	1.16	1.54	1.22	6.67	2.78	-	-	5	2.68	5.42	2.33
N	6	6	6	6	6	4	2	$F_1 = .88$			
\bar{X}	1.60	1.97	2.28	11.48	3.06	2.09	2.91	DF 5			
S ²	.20	.403	2.80	119.65	4.29	.05	4.06	DF 30			
S	.45	.635	1.67	10.94	2.07	.22	2.02	Null Hypothesis:			
								$- = - = \dots$			
								$x_1 \quad x_2$			
								$F_{.05} \text{ for } DF \frac{5}{30} = 2.53$			

 $F_2 = 3.27$

DF 6

DF 29

Null Hypothesis: $- = - = \dots$ $x_1 \quad x_2$ $F_{.05} \text{ for } DF \frac{6}{29} =$ $F_2 = 3.27 > 2.53$; reject H_0 *actual 25:0; use 25:0:1
for statistical comparison**actual 26:0; use 26:0:1
for statistical comparison $F_1 = .89 < 2.53$; do not
reject
 H_0

ANNEX N

EVALUATION

ANNEX N (EVALUATION)

I. General: The Study Group used the rationale and computations explained in this annex to develop the Cost Model for Criteria A and B and the Effectiveness Model for Criterion B. Appendices 1, 2, 4, 5, 7 and 8 provide the cost data for Criteria A and B, Scenarios #1 through #6. Appendices 3 and 6 provide the Effectiveness Data for Criterion B, Scenarios #2 and #4.

II. Cost Model (Criteria A&B, Scenarios #1 through #6)

a. The Study utilized the following Combat Power Coefficients (CPC) to total and compare the relative contributions of various systems in the defense:

- (1) M-60A1 = .7
- (2) TOW = .4
- (3) Dragon = .2
- (4) LAW = .1

(See ANNEX C [Combat Power])

b. Consequently the Combat Power (CP) of any organization was measured by the following formula:

$$CP = .7 (\# \text{ M-60A1s}) + .4 (\# \text{ TOWs}) + .2 (\# \text{ Dragons}) + .1 (\# \text{ LAWs})$$

For example: $CP_{4-4-3} = .7(53) + .4(12) + .2(12) + .1(12) = 45 \text{ utils}$

c. Using CPC, the following is the relative Combat Power of all organizations:

<u>Scenarios 1 thru 5</u>	<u>Scenario 6 (one tank co detached)</u>
$CP_{3-3-3} = 33.6$	$= 25.9$
$CP_{4-3-3} = 39.9$	$= 30.1$

CP ₃₋₄₋₃ =39.9	= 30.1
CP ₃₋₃₋₄ =41.3	= 33.6
CP ₄₋₄₋₃ =45.5	= 33.6
CP ₄₋₃₋₄ =46.2	= 37.1
CP ₅₋₃₋₃ =46.2	= 34.3

d. Inherently, the loss of a single tank represented a greater percentage loss of combat power to those organizations with fewer tanks than it did to the H series organization (533). The Study Group therefore realized that to measure cost only in terms of the percentage of organizational combat power lost would unfairly penalize the smaller (fewer M60A1's) organizations. Consequently, the cost of systems destroyed was held consistent across all organizations by fixing the util value assigned to each system but expressing losses as a percentage of the combat power of the largest organization (533, 46.2 utils). Put another way, this approach allowed a tank lost by any organization to be equal in value in all organizations. Thus a division or brigade commander with a fixed number of tanks at his disposal could compare costs suffered by different organizations in common terms. The differences in performance might be indicative then of inherent advantages in particular organizations, not in gross numbers of tanks in a battalion.

e. The formula for normalized costs expressed as a percentage is therefore:

Combat power lost by the organization (utils)
Combat power of largest organization (46.2 utils)

f. For example,

- (1) Situation: Scenario 5, Organization 333
- (2) Losses: M60A1 -6; TOW -4; Dragon -2; LAW -0.

$$\begin{aligned} (3) \text{ Combat Power Lost} &= (.7)(6) + (.4)(4) + (.2)(2) \\ &\quad + (.1)(0) \\ &= 6.2 \end{aligned}$$

$$(4) \text{ CP}_{\text{ORG}} = 33.6$$

$$\begin{aligned} (5) \text{ Loss (Cost) as percent of CP}_{\text{ORG}} &= \frac{6.2}{33.6} \\ &= \underline{18.4\%} \end{aligned}$$

(6) Normalized Loss (Cost) as percent of

$$\text{CP}_{533} = \frac{6.2}{46.2} = \underline{\underline{13.4\%}}$$

g. The Study used normalized cost data to compare and rank alternatives.

111. Effectiveness Model (Criterion B, Scenarios #2 + #4)

a. The Study utilized the following Combat Power Coefficients (CPC) to aggregate and compare the relative contributions of various Soviet systems in the offense:

- (1) T-62 = .7
- (2) BMP = .4

(See ANNEX C [Combat Power])

b. The Study then utilized the following formula to compute the effectiveness of the U.S. defense:

$$\text{Effectiveness} = .7 (\# \text{ T-62s killed}) + .4 (\# \text{ BMPs killed})$$

c. Since the Study in Criterion B fixed the cost for Scenarios #2 and #4 at 50 percent of U.S. Combat Power destroyed, the analyst had only to determine when that occurred, enter the Coroner's Report at that time, and count the aggregate of each type Soviet system killed.

d. By using the Effectiveness Model, the Study Group calculated the raw utils of Soviet Combat Power destroyed by a battalion and then compared battalions by this figure.

Appendices

1. Cost Data, Scenario #1
2. Cost Data, Scenario #2
3. Effectiveness Data, Scenario #3
4. Cost Data, Scenario #3
5. Cost Data, Scenario #4
6. Effectiveness Data, Scenario #4
7. Cost Data, Scenario #5
8. Cost Data, Scenario #6

Appendix 1 (Cost Data, Scenario #1) to ANNEX N (EVALUATION)

Soviet Force: Reinforced Tank Regiment
Initial Soviet Array = 31 BMP + 93 T-62
Established MOE = 47 T-62 Destroyed

ORGAN	Time Sec.	Soviet Losses		U.S. Losses			Utils Dest. Costs	CP ORG (Init.)	CP ORG	% CP (Norm)
		BMP	TYS	TKS	TOW	DRGN	LAW			
443	483	16	47	22	2	3	0	45.5	36.9	36.4
434	97	0	47	0	2	3	3	46.2	3.0	3.0
343	338	5	47	5	1	4	0	39.9	11.8	10.2
334	452	2	47	18	4	4	0	41.3	36.3	32.5
433	130	9	48	10	2	0	0	39.9	19.5	16.9
333	419	0	51	18	1	0	0	33.6	38.7	28.1
533	227	11	47	25	4	0	0	46.2	41.3	41.3

Notes:

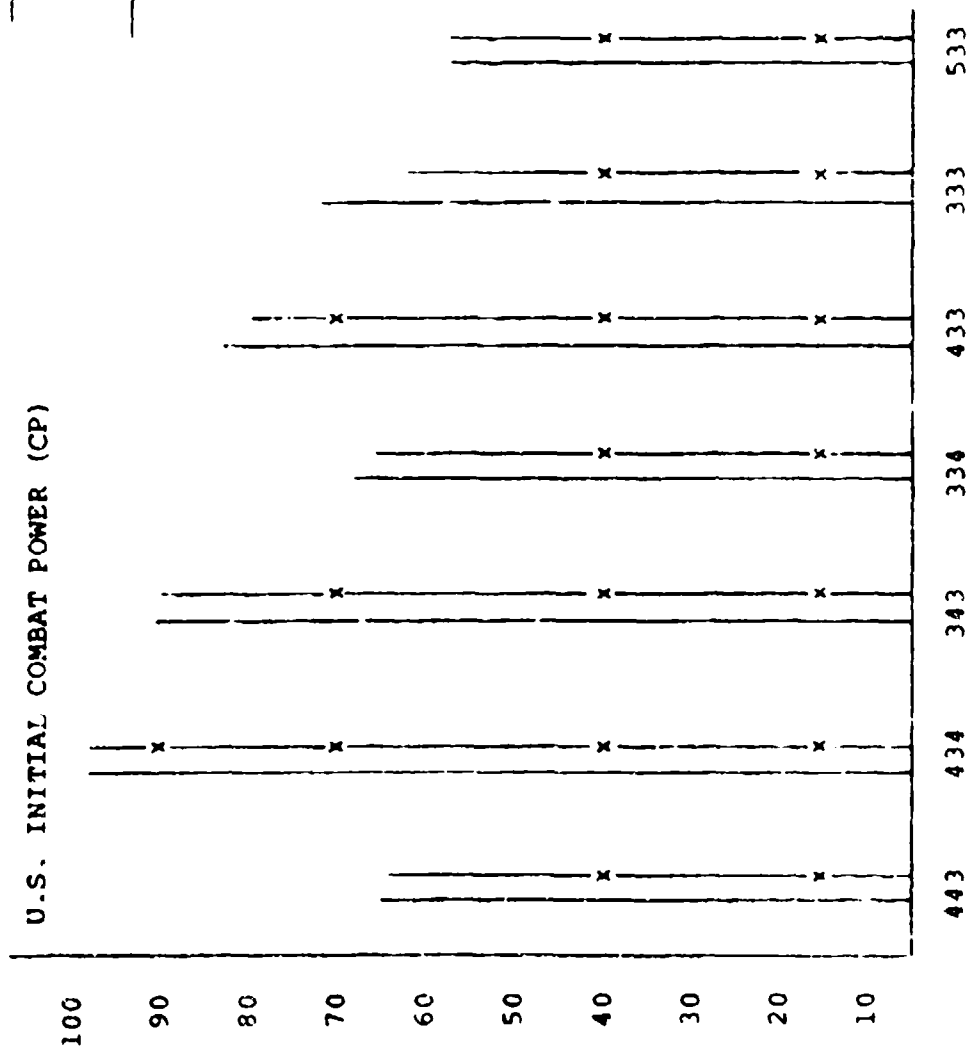
1. CP₅₃₃ = 46.2 utils

SCENARIO 1
FIXED EFFECTIVENESS:
MEASURE COST

MOE=500 T-62 Destroyed

Normalized U.S. Combat
Power Remaining After
Battle

Organization's Combat
Power Remaining After
Battle



Appendix 2 (Cost Data, Scenario #2) to ANNEX N (EVALUATION)

Soviet Force: 2 Reinforced Tank Regiments
Initial Soviet Array: 62 BMP + 217 T-62
Established MOE = 103 T-62 Destroyed

ORGAN	Time Sec.	Soviet Losses		U.S. Losses			Utils Dest. Costs	CP ORG (Init)	% CP ORG	% CP (Normalized)
		BMP	TKS	TKS	TOW	DRGN	LAW			
443	6032	20	752	37	2	8	8	45.5	64.0	63.0
434	6371	11	109	9	5	3	9	46.2	21.2	21.2
343	4858	6	108	42	9	8	0	39.9	86.7	74.9
334	6104	7	109	25	7	12	6	41.3	56.4	50.4
433	6088	9	109	25	4	7	5	39.9	52.6	45.4
333	6928	4	110	25	4	11	6	33.6	65.2	47.4
533	2653	27	1003	43	6	1	0	45.2	68.2	58.2

Notes:

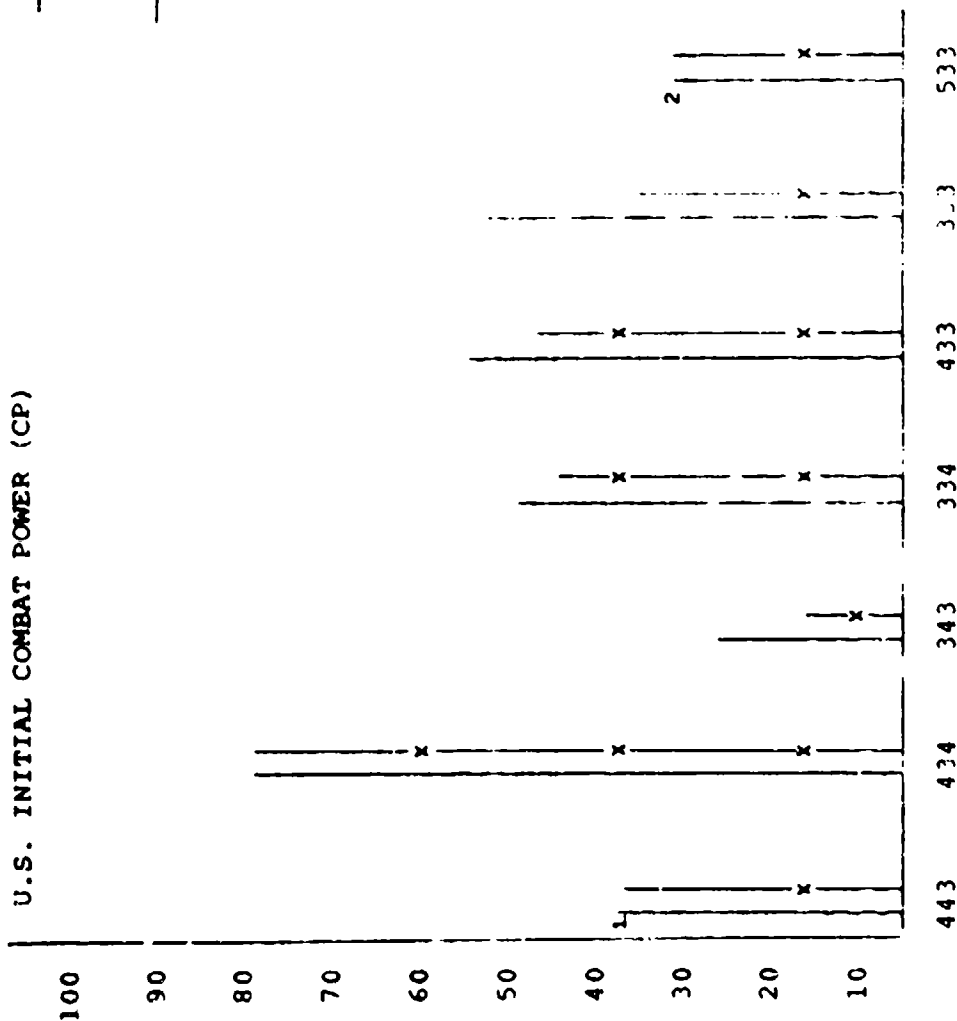
1. CP₃₃ = 46.2 utils
2. Only 35% of T-62 destroyed. Battle terminated for other tactical reasons (i.e., flank turned, position untendable).
3. Only 46% of T-62 destroyed. Balance of note 2 supplies.

SCENARIO 2
FIXED EFFECTIVENESS:
MEASURE COST

MOE=50% T-62 Destroyed

—— Normalized U.S. Combat Power Remaining After Battle

---x--- Organization's Combat Power Remaining After Battle



Notes: 1. Only 35% of T-62 Destroyed
2. Only 46% of T-62 Destroyed

Appendix 3 (Effectiveness Data, Scenario #2) to ANNEX N (EVALUATION)

Soviet Force: 2 Reinforced Tank Regiments
 Initial Soviet Array: 62 BMP + 217 T-62
 Established MOE = 50% U.S. Combat Power (CP)
 Measure of Effectiveness: Soviet Combat Power Destroyed

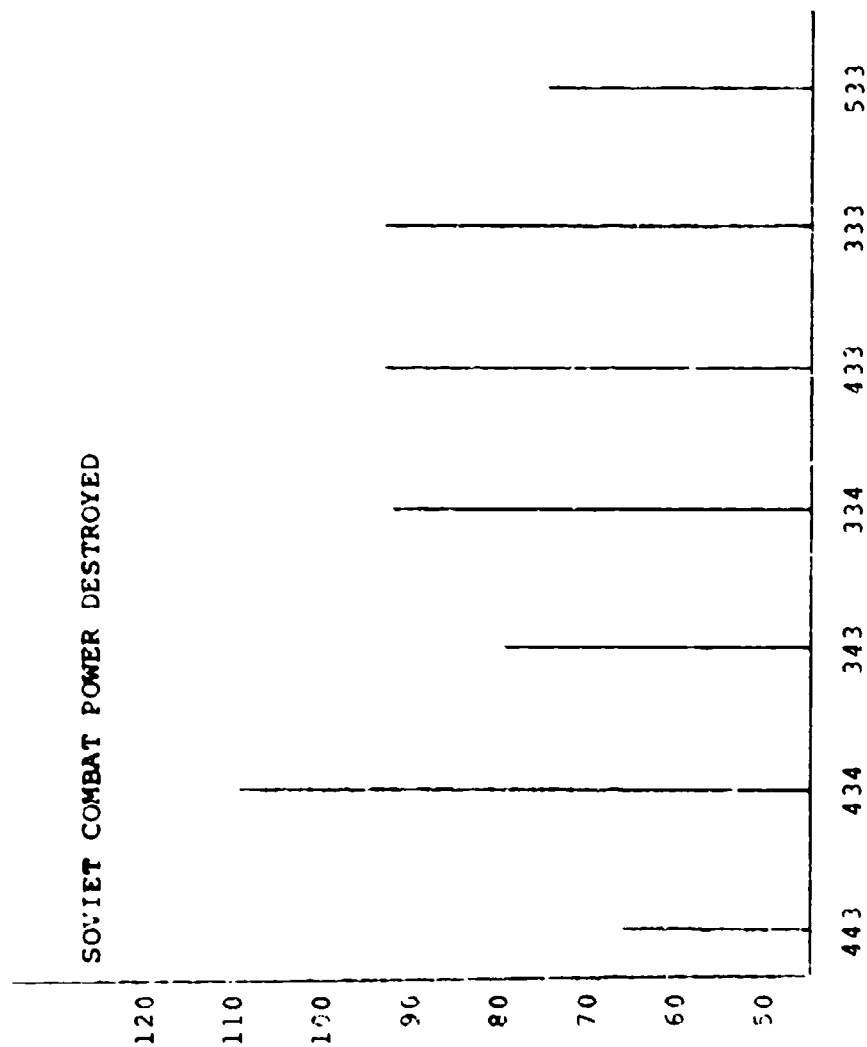
ORGAN	Time Sec.	Soviet Losses		U.S. Losses				U.S. Init CP	% Init CP Dest.	% CP (Norm- alized)	Soviet CP Dest.
		BMP	TKS	TKS	TOW	DRGN	LAW				
443	555	20	54	29	2	8	8	45.5	52	51	45.8
434	7048	31	147	27	5	7	9	46.2	50	50	115.3
343	4766	5	82	28	6	5	0	39.9	58	50	59.4
334	6114	7	111	20	7	10	1	41.3	56	50	80.5
433	6097	9	114	25	7	8	6	39.9	56	49	83.4
333	6956	6	117	25	4	11	6	33.6	65	47	84.3
533	2558	11	76	32	4	0	0	46.2	50	50	57.6

Note:

1. CP₅₃₃ = 46.2 utils

SCENARIO 2
FIXED COST:
MEASURE EFFECTIVENESS

MOC=50% U.S. Combat
Power Destroyed
(Normalized)



Appendix 4 (Cost Data, Scenario #3) to ANNEX N (EVALUATION)

Soviet Force: Reinforced Tank Regiment
Initial Soviet Array: 31 BMP + 93 T-62
Established MOE - 47 T-62 Destroyed

ORGAN	Time Sec.	Soviet Losses		U.S. Losses			Utils Dest.	CP ORG (Init)	% CP ORG	% CP (Normalized)
		BMV	TKS	TKS	TOW	DRGN	I.A.W			
443	182	0	49	3	0	0	0	45.5	4.6	4.5
434	184	0	47	0	3	0	3	46.2	3.2	3.2
334	392	0	48	0	3	7	0	41.3	6.3	5.6
433	241	0	48	5	2	3	0	39.9	13.5	11.7
333	158	0	47	6	4	2	0	33.6	18.4	13.4
533	183	0	47	3	3	0	0	46.2	7.1	7.1

Note:

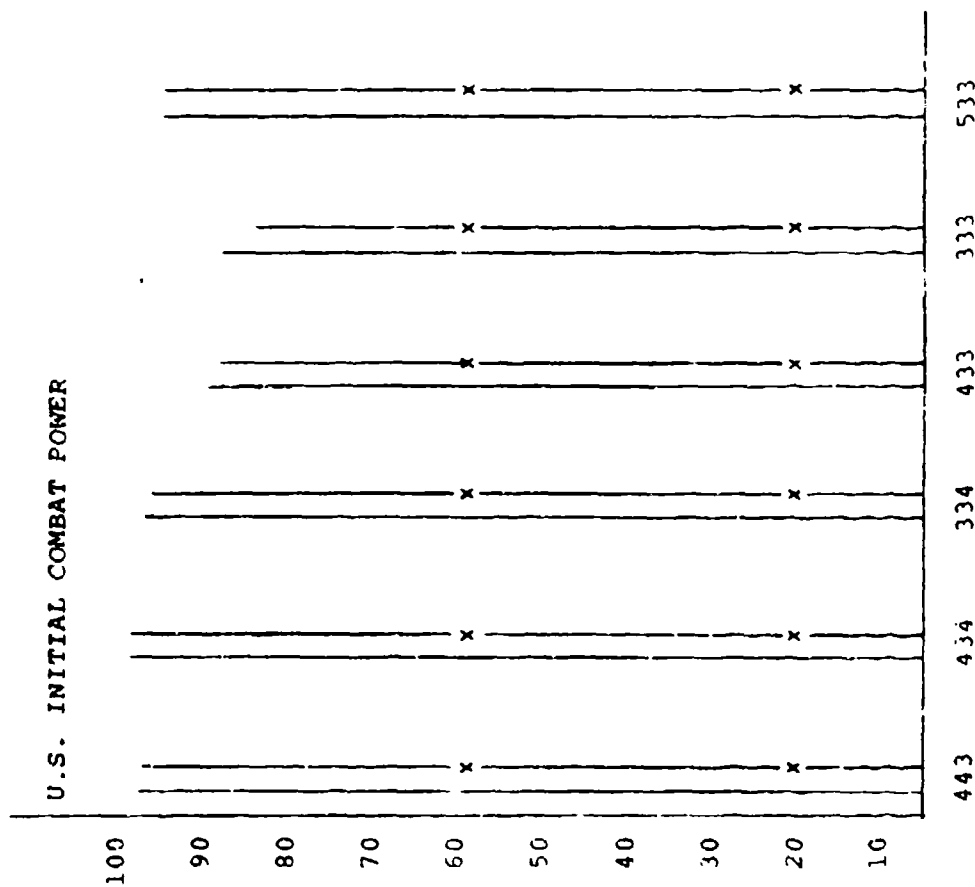
1. CP₅₃₃ = 46.2 utils

SCENARIO 3 FIXED EFFECTIVENESS MEASURE COST

MOE=50% DEST

—— Normalized U.S.
ComLat Power Remaining
After Battle

——x—— Organization's Combat
Power After Battle



Appendix 5 (Cost Data, Scenario #4) to ANNEX N (FVALUA) (ON)

Soviet Force: 2 Reinforced Tank Regiments
Initial Soviet Array: 52 BMP + 217 T-62
Established MC = 109 T-62 Destroyed

ORGAN	Time Sec.	Soviet Losses		U.S. Losses			Utils Dest. Costs	CP ORG (Init)	% CP ORG	% CP1 (Normalized)
		BMV	TKS	TKS	TOW	DRGN	LAW			
443	2532	14	111	21	6	0	0	45.5	32.3	31.8
434	4374	18	110	12	3	0	3	46.2	21.4	21.4
334	3302	6	112	10	3	7	0	41.3	23.2	20.8
433	5446	8	100 ²	25	9	3	3	39.9	55.1	47.6
333	4440	13	109	23	8	6	3	33.6	61.9	45.0
533	3373	11	111	24	1	0	1	45.2	37.4	37.4

Notes:

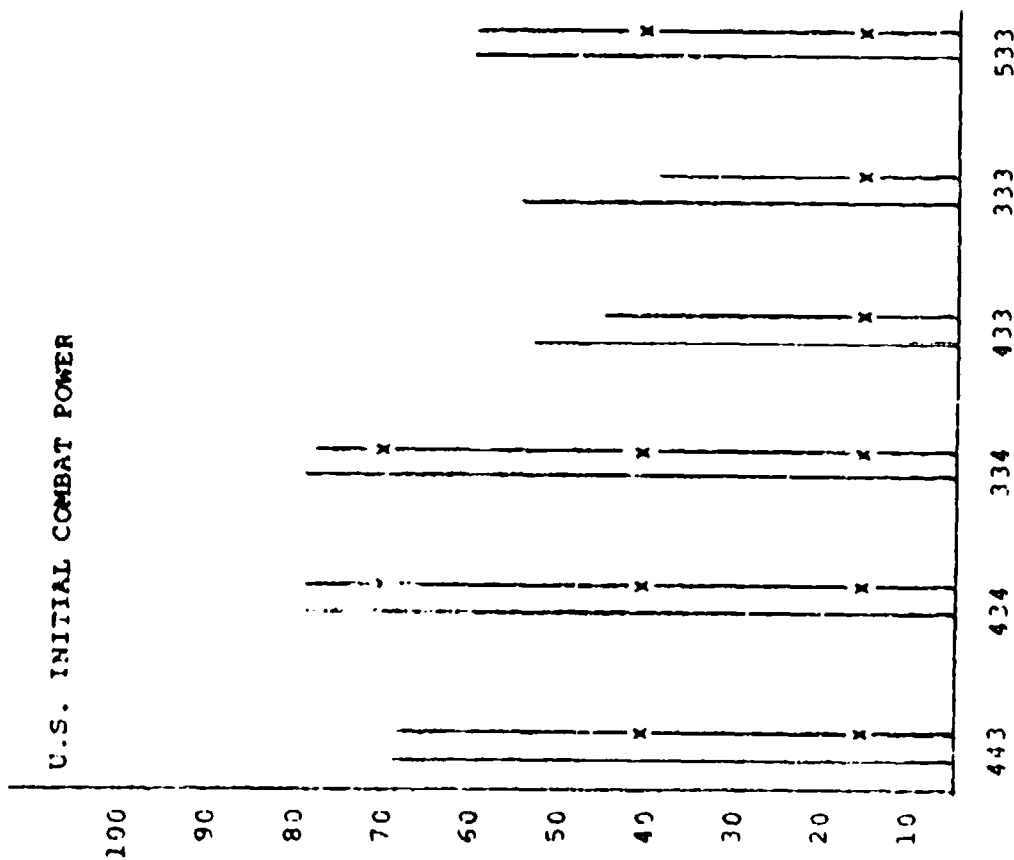
1. CP₅₃₃ = 46.2 utils
2. Only 46% of T-62 Destroyed. Battle terminated to accomplish extraction before position became untenable.

SCENARIO 4
FIXED EFFECTIVENESS:
MEASURE COST

MOE=50% T-62 Destroyed

— Normalized U.S. Combat
Power Remaining After
Battle

—x— Organization's Combat
Power Remaining After
Battle



Appendix 6 (Effectiveness Data, Scenario #4) to ANNEX N (EVALUATION)

Soviet Force: 2 Reinforced Tank Regiments
 Initial Soviet Array: 62 BMP + 217 T-62
 Established MOC = 50% U.S. Combat Power (CP) Destroyed (Normalized)
 Measure Effectiveness: Soviet Combat Power Destroyed

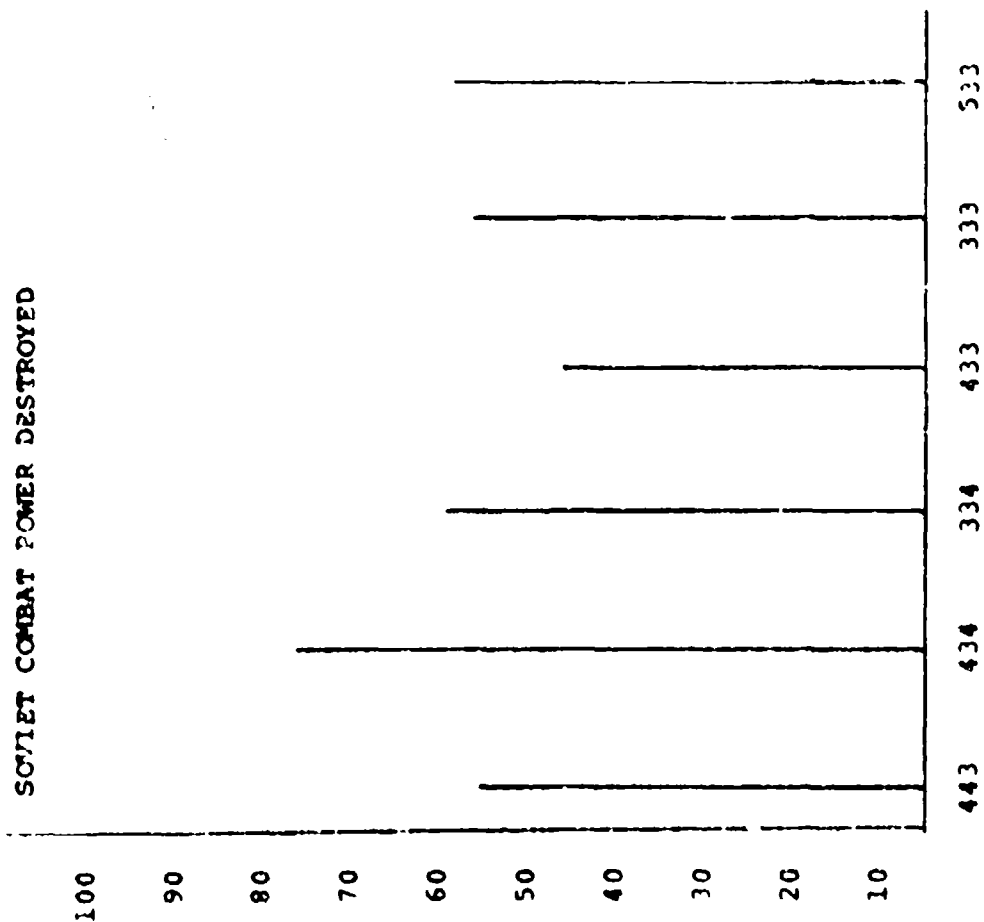
ORGAN	Time Sec.	Soviet Losses		U.S. Losses			U.S. Init. CP	Init. CP Dest.	CP Dest. (Norm)	Soviet CP Dest.
		BMY	TKS	TKS	TOW	DRGN				
443	2670	19	122	30	6	0	45.5	53	52	93.0
434	4589	39	164	30	3	0	46.2	50	50	130.4
334	3376	7	129	28	4	7	41.3	55	50	93.1
433	6446	8	100	25	9	3	39.9	55	48	73.2
333	5535	13	121	23	8	6	33.6	50	45	89.9
533	3408	16	125	32	1	0	46.2	50	50	93.9

Note:

i. CP₅₃₃ = 46.2 utils

SCENARIO 4
FIXED COST:
MEASURE EFFECTIVENESS

MOC-508 U.S. CP
(Normalized)



Appendix 7 (Cost Data, Scenario #5) to ANNEX N (EVALUATION)

Soviet Force: Reinforced Tank Regiment
 Initial Soviet Array: 31 BMP + 93 T-62
 Established MOE = 47 T-62 Destroyed

ORGAN	Time Sec.	Soviet Losses		U.S. Losses			Utils Dest. Costs	CP ORG (Init.)	CP ORG	CP (Normalized)
		BMY	TKS	TKS	TOW	DRGN	LAW			
443	270	10	47	19	0	1	0	45.5	29.5	29.0
434	92	18	47	9	0	0	0	46.2	13.6	13.6
433	102	21	47	7	0	0	0	39.9	12.2	10.6
333	94	11	47	18	0	0	0	33.6	37.5	27.3
533	95	16	47	12	0	0	0	46.2	18.2	18.2

Notes:

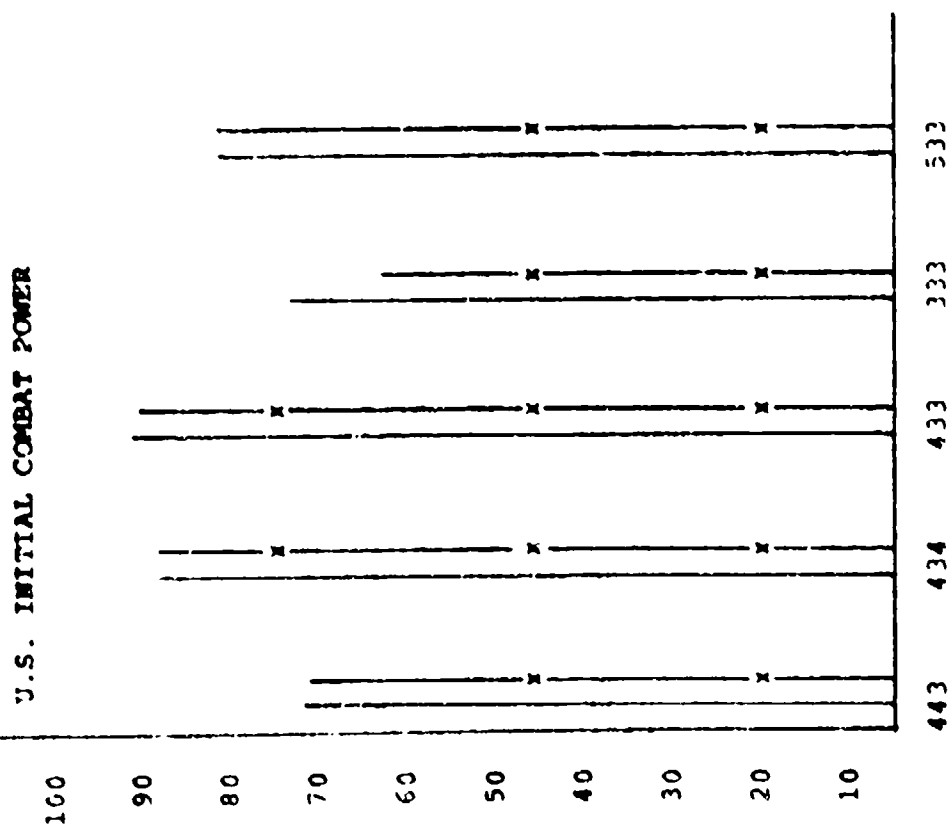
1. CP₅₃₃ = 46.2 utils

SCENARIO 5
FIXED EFFECTIVENESS:
MEASURE COST

MOE-50s 7-62 Destroyed

— Normalized U.S. Combat
Power Remaining After
Battle

—x— Organization's Combat
Power Remaining After
Battle



Appendix 8 (Cost Data, Scenario #6) to ANNEX N (EVALUATION)

Soviet Force: Reinforced MTZD Rifle Regiment
 Initial Soviet Array: 93 BMP + 40 T-62
 Established NOE = 47 BMP Destroyed

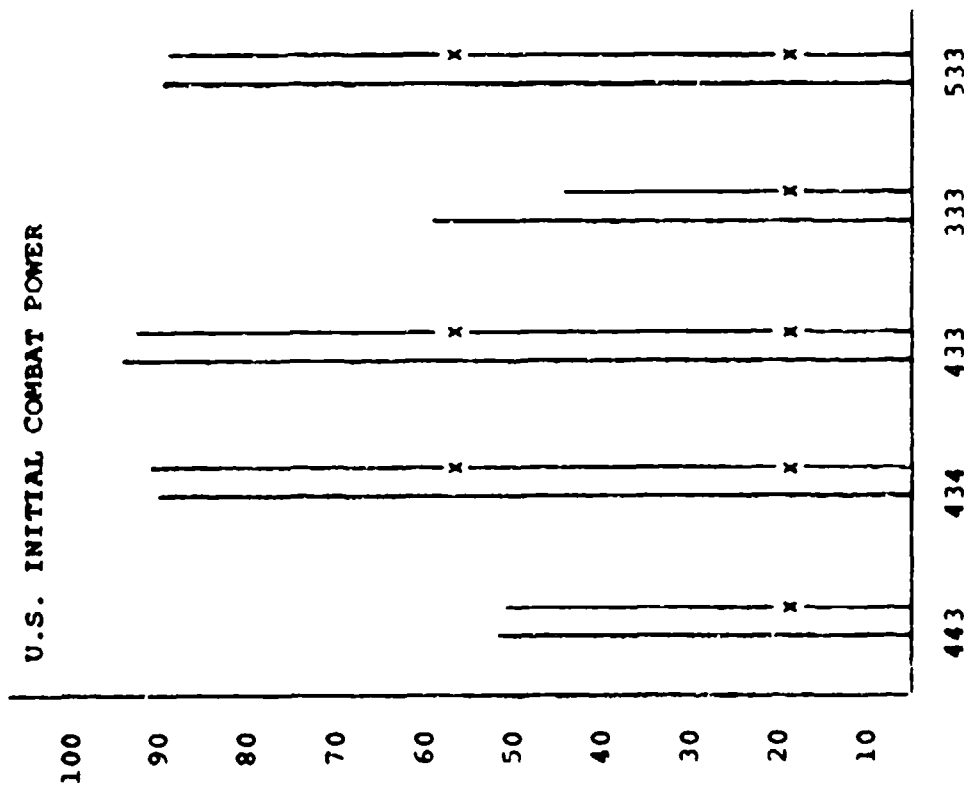
ORGAN	Time Sec.	Soviet Losses		U.S. Losses			Utils Dest. Costs	CP ORG (Init.)	CP ORG	CP (Normalized)
		BMV	TKS	TKS	TOW	DRGN	LAW			
443(2)	186	47	25	20	5	1	0	33.6	48.2	47.2
434(3)	144	47	20	5	0	0	0	37.1	9.4	10.2
433(2)	217	47	16	2	2	0	2	28.0	8.6	6.9
333(2)	186	47	24	18	1	6	3	25.9	56.0	42.3
533(2)	210	47	16	3	4	1	0	34.3	11.7	11.7

Notes:

1. $CP_{533} = 34.3^2$ utils
2. U.S. organization detached. One Tank Company; received one Mech Infantry Company as cross reinforcement.

SCENARIO 6
FIXED EFFECTIVENESS:
MEASURE COST

MOZ=50% BMP Dest.
— Normalized U.S. Combat
Power Remaining After
Battle
-x- Organization's Combat
Power Remaining After
Battle



ANNEX O

NON QUANTIFIABLE FACTORS

ANNEX O (Non Quantifiable Factors)

I. Early in the analysis, the Study Group recognized that many of the important indicators of performance were not subject to quantification. The most significant of these qualitative indices of performance concerned the alternative organizations' capabilities in command and control, responsiveness, employability, sustainability, and flexibility. (See Appendix 1 [Qualitative Summary by Battalion Organization]).

II. COMMAND AND CONTROL

a. Leadership attrition had a significant influence on the effectiveness of a number of the alternative organizations particularly at the platoon level. However, the most important factor in command and control was the span of control, an exceptionally difficult problem to analyze with BATTLE. In the end, the Study Group simply watched the differing situations develop on the terrain boards and speculated from experience what would be the problems or advantages of each alternative organization.

b. Platoon Organization

(1) Three Tank Platoon:

(2) The three tank platoon never experienced leadership attrition so severe as to render a platoon combat ineffective. To achieve this, however, the Army would have to man two out of every three tanks with leaders, and this would be poor utilization of our NCO corps.

(b) The span of control was excellent. The platoon leader easily led this platoon using hand and arm signals and few radio transmissions. The Study Group speculated from the battle situations on the terrain boards that this platoon would not need a radio net and could operate with all tanks tuned to the company frequency.

(2) Four Tank Platoon:

(a) The four tank platoon only once experienced leadership attrition (loss of both the platoon leader and platoon sergeant) so severe as to render an otherwise viable platoon combat ineffective. Consequently, loss of effectiveness due to leadership attrition does not appear to be an endemic problem with the four tank platoon.

(b) Intuitively, the span of control in a four tank platoon is not as good as in a three tank platoon. The four tank platoon can deploy and maneuver as two sections, and this capability in particular made command and control more difficult in a four tank platoon. A four tank platoon needs its own radio net, and its platoon leader cannot totally control the platoon with hand and arm signals.

(3) Five Tank Platoon:

(a) In almost every iteration, some five tank platoons suffered loss of combat effectiveness because leadership attrition is a real weakness of the five tank platoon.

(b) Because both the four and five tank platoons can deploy and maneuver as two sections, the span of control is almost identical in both organizations. The platoon leader can not totally control his platoon with hand and arm signals and the platoon must have its own radio net, but the span of control is well within the capabilities of the platoon leader and platoon sergeant.

c. Company Organization

(1) Three Platoons: Experience and the game boards conclusively indicate that the company commander can easily control three platoons. Furthermore, the Study Group saw no indication that the company commander needed the assistance of a second in command to command and control three platoons.

(2) Four Platoons: While it was exceptionally difficult to gauge the span of control difficulties of a commander with four platoons, the Study Group saw numerous fast breaking situations where a Company Commander would have had real command and control problems with four maneuver elements. The conclusion of the Study Group is that four platoons exceed the span of control of a tank company commander.

d. Battalion Organization

(1) Three Companies: Again operational experience and BATTLE clearly indicate that three companies are well within the span of control of the Battalion Commander and his staff.

(2) Four Companies: The operational experience of the Study Group and the iterations of BATTLE also show that a four company battalion, even with an organic TOW company and an attached Mechanized Infantry Company, is within the effective command and control of the Battalion Commander and his staff. The Regimental Armored Cavalry Squadron is an excellent example of a combat formation that habitually operates with four maneuver units (three Troops and one Tank Company) and two support units (an organic Howitzer Battery and an attached or direct support Engineer Company). Quite often in defensive missions, moreover, the Armored Cavalry Squadron receives the attachment of a second tank company, so four maneuver companies is not the upper limit of the Battalion or Squadron Commander's span of control. However, when a battalion is organized with more than three companies the S-3 or Deputy Battalion Commander must play a role almost equal to that of the Commander in the control of the battalion.

III. RESPONSIVENESS

a. Responsiveness in a battalion was a direct function of responsiveness in the individual companies since most battalions move, maneuver, and deploy on multiple routes. Responsiveness in the companies was a function of the size and number of platoons assigned to it. At the platoon level, responsiveness was directly correlated with ease and speed of occupying and extracting from a platoon battle position.

b. Platoon Organization

(1) Three Tank Platoon: The three tank platoon was the most responsive of the three alternative platoon organizations.

(2) Four Tank Platoon: The four tank platoon was as easy or easier to position on the battlefield as the three tank platoon. Most platoon battle positions, without degrading the contribution of individual tanks, facilitated four tanks as smoothly as three. The four tank platoon had the added advantage over the three tank platoon of being capable of positioning by two tank sections which allowed the four tank platoon to use terrain that the three tank platoon could not use. The four tank platoon by virtue of its extra tank, however, could not occupy and extract from a position as quickly as a three tank platoon.

(3) Five Tank Platoon: The five tank platoon in comparison with the three or four tank platoon was simply cumbersome. Far too often, the five tank platoon had to occupy platoon battle positions which severely limited the performance and participation of one of the five tanks in the platoon. Furthermore, the five tank platoon was substantially slower in occupying and extracting from positions particularly when it operated in close proximity to other platoons of the company.

c. Company Organization

(1) Three Platoon Companies: Three platoon companies whose platoons had only three or four tanks proved highly responsive. However, 5-3-3 with a total of 17 tanks in the company suffered degradation of responsiveness on numerous occasions from too many tanks in a constricted area.

(2) Four Platoon Companies: Four platoon companies were the most unresponsive organizations regardless of the size of the platoons of any company organization tested. On numerous occasions four platoon companies had difficulty finding a good platoon battle position for the fourth platoon that would contribute to the Company effort. Far too often, one platoon was unable to extract cleanly and got cut off and totally destroyed.

IV. EMPLOYABILITY

a. Employability refers to the viability, potential for cross attachment, and potential for tactical deployment that various size organizations offer their commanders.

b. Platoons

(1) Three Tank Platoon: The three tank platoon suffered from severe viability limitations. Without the ability to operate in sections, the three tank platoon cannot operate separate from its parent company. This in turn severely limits the tank company as an asset when attached to a Mechanized Infantry Company. Furthermore, if a three tank platoon lost one tank it almost ceased to exist as a viable force.

(2) Four Tank Platoon: The four tank platoon was the most employable platoon of the battlefield.

(3) Five Tank Platoon: The five tank platoon proved almost equally employable.

c. Company Organization: Of all the company alternatives only 4-4-3 had a distinctly unique and advantageous characteristic. With four platoons of four tanks, 4-4-3 had an additional viable platoon capable of independent operations that it could attach out. Therefore, 4-4-3 could send a particularly useful company to a mechanized infantry battalion in a cross attachment.

d. Battalion Organization:

(1) Three Company Battalion: When defending against a Soviet regiment, the three company battalion suffered a severe problem that usually cost it one company destroyed. The Soviets in a breakthrough attack advance with two battalions abreast and one trailing. This usually meant that two tank companies of the U.S. battalion engaged one Soviet battalion while the third company fought the second Soviet battalion alone. The result was that the third company was totally destroyed. Moreover, when the three company battalion had to cross attach a company, the battalion was close to losing its viability.

(2) Four Company Battalion: The four company battalion is a two axis of advance organization. Four companies were ideally suited for fighting the two pronged Soviet

breakthrough attack because this battalion could match two companies against each Soviet battalion. Furthermore, the four company alternative could cross attach one company and still have a strong battalion remaining.

V. SUSTAINABILITY

a. Sustainability is a measure of an organization's ability to remain viable as an organization when it begins to take losses.

b. Platoon Organizations:

(1) Three Tank Platoon: The three tank platoon is organized one tank away from losing its viability. If any mishap of maintenance or battle loss caused a loss the platoon lost its viability.

(2) Four Tank Platoon: The four tank platoon was the most viable platoon organization of tanks because it had a two tank margin of viability. Moreover, the four tank platoon never experienced situations in which platoons lost all of their leadership and left the platoons without leadership.

(3) Five Tank Platoons: The five tank platoon obviously had the greatest sustainability in tanks but repeatedly experienced problems with lost leadership and leaderless platoons.

c. Company Organization: The company organized with as few as ten tanks - simply did not have enough sustainability in its platoons to remain a viable company through

too many losses. The seventeen tank companies had the best sustainability and it could usually "solve" its leadership crises in the platoons by "cross leveling" its leaders. The companies with 13 tanks had good sustainability while not as good as the 17 tank companies.

d. Battalion Organisation: The 4-3-4, 4-4-3, and 5-3-3 had the gross number of tanks necessary to sustain these organizations into the fight against the second echelon of a Soviet division attack. The 3-3-3 battalion did not have the gross number of tanks to fight more than one battalion.

VI. FLEXIBILITY

a. If the number of tanks in an armored division remains constant, the division could organize nine battalions in a 3-3-3 configuration. This obviously has implications on the battlefield flexibility afforded commanders above battalion at brigade and division levels. The following chart depicts the battlefield flexibility afforded commanders from the platoon to the division level by various organizations:

<u>BN ORGAN</u>	<u>MINIMAL</u>	<u>FAIR</u>	<u>GOOD</u>	<u>EXCELLENT</u>
3-3-3 (36)	Plt Ldr(1) Co CO(1&5)	BN CO(1&5)	Bde CO(2,3,4) Div CO(2,3,4)	
5-3-3 (54)	Plt Ldr(2,3,4)	Co CO(2&3) Bde CO(2&4) Div CG(5)	BN CO(1)	
4-4-3 (53)		Co CO(2&4) BN CO(2) Div CG(2&3)	Plt Ldr(2&3) Bde CO(5)	

<u>BN ORGAN</u>	<u>MINIMAL</u>	<u>FAIR</u>	<u>GOOD</u>	<u>EXCELLENT</u>
4-3-3 (45)		BN CO (1&5)	Plt Ldr (2&3) CO CO (2&3) Bde CO (2&3) Div CG (2&3)	
4-3-4 (54)			Plt Ldr (2&3) BN CO (1, 2, Co CO (2&3) 3, 4, Bde CO (1&5) 5) Div CO (1&5)	

Factors Considered in Determinations:

- (1) Sustainability
- (2) Responsiveness
- (3) Maneuverability
- (4) Ease of Positioning
- (5) Ease of Cross Attachment

Appendices

1. Qualitative Summary by Battalion Organization

Appendix 1 (Qualitative Summary by Battalion Organization to ANNEX O (Non Quantifiable Factors))

3-3-3

Advantages

- Excellent command & control
- Leadership during the battle was plentiful
- Weak tanks receive more attention because of reduced span of control.
- Highly responsive.

Disadvantages

- Lacks combat power, particularly in a low visibility scenario.
- Organized too close to the margin.
- Highly sensitive to the OR rate.
- Unforgiving organization.
- Platoons must be employed as a company.
- Difficult to cross attach.

3-4-3

Advantages

- Excellent command and control at platoon level
- Good combat power at company and battalion level.

Disadvantages

- Lacks combat power at platoon level.
- Difficult to effectively employ four platoons in company position.
- Companies are less responsive.
- Difficult to cross attach.
- Company Commander is overloaded.

3-3-4

Advantages

- Excellent command & control at platoon & company level.
- Adequate command & control at battalion level.
- Weak tanks receive more attention because of reduced span of control.
- Combat power in the battalion is adequate.
- Leadership during the battle was plentiful.
- Added flexibility afforded by the fourth company.
- Excellent for cross attachment.

Disadvantages

- Lacks combat power at platoon level.
- Highly sensitive to the OR rate.
- Platoons must be employed as a company.

4-3-4

Advantages

- Combat power at platoon, company & battalion level is excellent.
- Good command & control at platoon & company level.
- Adequate command & control at battalion level.
- Adequate leadership throughout the battle.
- More flexibility at platoon level.
- Added flexibility afforded by the fourth company.
- Excellent for cross attachment.

Disadvantages

O-12

5-3-3

Advantages

- Excellent combat power.
- Particularly strong in low visibility and limited terrain scenario.

Disadvantages

- Cumbersome, unresponsive.
- Inefficient target servicing.
- Prone toward leadership crises.
- Difficult to deploy on the terrain at platoon, company and battalion level.

4-3-3

Advantages

- Combat power at platoon, company, and battalion level is excellent.
- Good command & control at platoon, company & battalion level.
- Adequate leadership throughout the battle.
- More flexibility at platoon level.

Disadvantages

- Experiences degradation when cross attached.

4-4-3

Advantages

- Excellent combat power.
- Good Command & Control at platoon and Battalion
- Adequate leadership throughout the battle
- More flexibility at platoon level.

Disadvantages

- Cumbersome, unresponsive.
- Difficult to deploy on the terrain at Co level.
- Experiences significant degradation when cross attached.
- Co CO overloaded

0-13

ANNEX P

LEADERSHIP LOST

ANNEX P (Leadership Lost)

A. Losses by Scenario

Scenario #1

	4-3-3	3-4-3	3-3-4	3-3-3
BN CO	0	0	0	0
Forward Obs	0	2	2	1
Forward Air Cntl	1	0	0	0
Company CO	0	1	2	2
Plt Ldr	3	3	7	6
Plt Sgt	5	2	5	6

	4-3-4	4-4-3	5-3-3
Deputy BN CO	0	1	0
Forward Obs	0	0	2
Forward Air Cntl	0	0	1
Company CO	0	0	2
Plt Ldr	1	6	4
Plt Sgt	0	10	8

Scenario #2

	4-3-3	3-4-3	3-3-4	3-3-3
BN CO	0	1	0	0
Deputy BN CO	0	1	0	0
Forward Obs	3	3	2	1
Forward Air Cntl	1	1	1	1
Company CO	1	2	2	2
Plt Ldr	7	12	12	8
Plt Sgt	8	14	8	7

	4-3-4	4-4-3	5-3-3
BN CO	1	0	0
Deputy BN CO	0	1	0
Forward Obs	0	0	3
Forward Air Cntl	0	0	1
Company CO	3	0	3
Plt Ldr	9	8	9
Plt Sgt	11	12	10

Scenario #3

	4-3-3	3-3-4	3-3-3	4-3-4	4-4-3	5-3-3
Forward Obs	0	1	0	0	0	0
Company CO	0	1	1	0	1	0
Plt Ldr	3	5	4	1	1	2
Plt Sgt	1	3	5	1	0	4

Scenario #4

	4-3-3	3-3-4	3-3-3	4-3-4	4-4-3	5-3-3
Forward Obs	1	3	2	0	0	1
Company CO	0	3	3	2	3	1
Plt Ldr	6	8	8	10	8	7
Plt Sgt	8	9	8	13	10	8

Scenario #5

	4-3-3	3-3-3	4-3-4	4-4-3	5-3-3
Forward Obs	1	2	0	0	0
Company CO	1	2	1	0	0
Plt Ldr	4	6	4	7	6
Plt Sgt	4	6	2	7	4

Scenario #6

	4-3-3(2)	3-3-3(2)	4-3-4(3)	4-4-3(2)	5-3-3(2)
BN CO	0	1	0	0	0
Deputy BN CO	0	0	0	0	1
FAC	0	1	0	0	0
Forward Obs	0	2	0	0	0
Company CO	0	1	0	1	1
Plt Ldr	3	6	2	6	4
Plt Sgt	4	6	0	7	2

B. Rank Ordering of Alternatives by Scenario (Utils lost)

Scenario #1 Scenario #2 Scenario #3

4-3-4(1)	4-3-3(19)	4-3-4(2)
4-3-3(8)	4-4-3(20)	4-3-3(4)
3-4-3(9)	3-3-3(23)	4-4-3(5)
4-4-3(16)	3-3-4(28)	5-3-3(6)
3-3-4(20)	5-3-3(31)	3-3-4(12)
5-3-3(20)	4-3-4(36)	3-3-3(13)
3-3-3(20)	3-4-3(45)	

Scenario #4 Scenario #5 Scenario #6

4-3-3(14)	4-3-4(10)	4-3-4(2)
5-3-3(19)	5-3-3(10)	4-3-3(11)
3-3-3(28)	4-3-3(12)	5-3-3(15)
3-3-4(29)	4-4-3(14)	4-4-3(17)
4-4-3(30)	3-3-3(20)	3-3-3(22)
4-3-4(31)		

Battalion Commander = 6 Utils
Deputy Battalion Commander = 5 Utils
Company Commander = 4 Utils
Platoon Leader = 1 Util
Platoon Sergeant = 1 Util

C. Rank Ordering by Alternative (% of leadership utils remaining)

4-3-4 (73%)

4-3-3 (69%)

4-4-3 (64%)

5-3-3 (59%)

3-3-3 (49%)

D. Discussion

This is a highly simplified analysis. Scenario #2 and #4 allowed the U.S. battalion to fight on until losses or the tactical situation forced a passage of lines or hand off of the battle. This analysis is consequently decidedly unfavorable to 4-3-4 which never had to hand off the battle because it defeated the entire Soviet force. In order to accomplish this, however, 4-3-4 had to exchange fire with the Soviets for a much longer period.

This analysis also made no adjustments for the density of leadership in each alternative. Therefore, the leadership in 3-3-3 was statistically much more exposed with the game rules allowing the Soviets perfect fire distribution. In this respect, 5-3-3 statistically exposed its leadership least to Soviet fire.

ANNEX Q

COMBAT POWER REMAINING

ANNEX Q (Combat Power Remaining)

A. Percentage of Combat Power Remaining at the End of Each Scenario by Rank Order

Scenario #1	Scenario #2	Scenario #3
4-3-4 97%	4-4-3 39%	4-3-4 97%
3-4-3 89%	3-3-3 37%	5-3-3 89%
4-3-3 62%	4-3-3 36%	4-4-3 81%
3-3-4 62%	4-3-4 30%	4-3-3 81%
5-3-3 54%	3-3-4 30%	3-3-4 76%
3-3-3 53%	5-3-3 24%	3-3-3 69%
4-4-3 49%	3-4-3 09%	
Scenario #4	Scenario #5	Scenario #6
4-3-3 42%	4-3-4 81%	4-3-4 88%
3-3-4 42%	5-3-3 73%	5-3-3 73%
3-3-3 36%	3-3-3 69%	4-3-3 64%
5-3-3 32%	4-3-3 68%	4-4-3 39%
4-3-4 29%	4-4-3 56%	3-3-3 33%
4-4-3 22%		

B. Rank Ordering by Average Percentage Remaining

4-3-4 70%
4-3-3 59%
5-3-3 57%
3-3-3 50%
4-4-3 48%

C. Discussion

This rather simplified analysis makes no attempt to equalize the different performances of the alternatives during scenarios #2 and #4. In particular, 4-3-4 killed substantially more Soviet armored vehicles than any other alternative; however, to accomplish this, 4-3-4 had to stay longer and suffer more casualties.

For scenarios #1, #3, #5, and #6 where effectiveness was fixed, this analysis is decidedly more accurate.

ANNEX R

TACTICAL LESSONS LEARNED

ANNEX R (Tactical Lessons Learned)

1. Complementary Nature of Various Weapons Systems

a. The TOW and Tank were a particularly complementary and deadly defensive team. Battalion commanders tended to employ the TOW/Tank team in one of the two ways.

(1) Most often, commanders emplaced TOW platoons approximately 1000 meters behind the tank platoons. Depending on intervisibility, this allowed the TOW's and tanks to open fire simultaneously with the TOW's firing at 2500 to 3000 meters and the tanks firing at 1500 to 2000 meters. The tanks, at the nearer range, attracted most, if not all, of the Soviet direct fire while the TOW's received little or no fire and could track their missiles with little distraction. T-62s firing from 1500 to 2000 meters at M-60A1s in hull defilade were not highly effective. Therefore the U.S. tanks, while suffering some losses, did not suffer debilitating losses. Then, as the Soviet battalion closed to within effective range of the T62s, the M-60A1 platoons backed into total defilade and allowed the TOW's at the greater ranges to complete the destruction of the Soviet battalions.

(2) Tank battalion commanders occasionally employed a technique of initially collocating TOW and tank platoons at the same general range from the Soviets. The TOW platoons opened the battle by engaging the Soviet battalion at maximum ranges. The TOWs then backed into total defilade and redeployed to subsequent positions 800 to 1000 meters behind

the tanks. The tank platoons allowed the Soviets to close to 1700 to 2000 meters and engaged. When the Soviets closed to within 1300 to 1500 meters, the M-60 platoons backed into defilade and allowed the repositioned TOW platoons to finish the defeat of the Soviet battalions.

(3) While none of the battles were as simple as just portrayed, the U.S. battalions employed some variation of the two above strategies that capitalized on the complementary nature of the two systems' ranges and rates of fire.

b. Given the right terrain, tanks and infantry complemented each other but only if commanders avoided certain pitfalls. Infantry anti-armor weapons (Dragon and LAW) could not be moved rapidly around the battlefield and still be employed effectively against Soviet breakthrough tactics. This was the most significant limitation in the infantry's contribution on the battlefield. The infantry platoons of the infantry company made their greatest contribution to the tank battalions' active defenses by manning strong points or mini-strong points. As such, these strong points most often served to anchor the flanks of the battalion battle positions. These strong points were most effective when the following conditions existed: the strong point was overwatched by tanks positioned not more than 700 meters behind the position (both to provide mutually supporting fires and to cover routes of egress suitable for M113A1s) and the number of T-62s/BMPs attacking the strong point did not

exceed 1.5 times the number of Dragons. If any one of these conditions was absent, the Soviets usually destroyed the strong point or bypassed it. The overwatch of the tanks was critical; if the Soviets destroyed the tank overwatch, screened it with smoke, or suppressed it with direct fire, the infantry strong point was doomed. When the conditions were right, Dragon gunners and tanks proved complementary and most effective. The tanks attracted all or a vast majority of the fire leaving the Dragon gunners free to track their missiles with little or no suppression.

c. TOWs and Dragons did not complement each other nearly as well as the Tanks and Dragons or TOWs and Tanks did.

(1) When the TOWs were in their optimum positions to engage Soviet armored vehicles, the Dragons were out of position for optimum employment and vice versa.

(2) When the TOW platoons had intervisibility and could engage at 2200 to 3000 meters, the Dragons were out of range and remained out of range for such a long period that the TOWs absorbed, for extended periods, the fires of whole Soviet battalions with disastrous results.

(3) When the battalion commanders moved the Dragons further forward in order that the TOWs and Dragons could engage simultaneously, their combined rate of kills on a Soviet tank battalion was not sufficiently fast to keep the Soviets from overrunning the Dragons.

(4) If the battle position commander elected to allow the Soviets to approach to within 1000 meters of the Dragons and 2000 meters of the TOWs, again their combined rate of kills was not fast enough to keep the Soviets from overrunning the Dragons and killing numerous TOWs.

(5) When intervisibility limited maximum opening ranges to about 1200 meters (an infantry avenue of approach), TOW platoons could not optimize their long range capabilities and possible positions for M113 mounted TOWs were substantially fewer than those available for Dragons.

2. Employment of the TOW Company

a. Regardless of their attachment, Battalion and Company Commanders almost always employed the TOW platoons in positions of overwatch for tank and infantry platoon battle positions. Only when visibility was exceptionally limited (1000 meters), did battle position commanders employ the TOW platoons in contiguous or colocated battle positions with tank and infantry platoons.

b. During the six scenarios, Battalion commanders had to deploy their companies over eight different battalion battle positions. The organization of tanks within the battalion had no effect upon attachment or cross attachment of the TOW platoons. The terrain, however, did have a major impact on employment of TOW platoons. In three of the battle positions, battalion commanders employed their TOWs in pure companies. In two of the three cases, the battle positions

possessed a large, dominant piece of terrain from which TOW platoons could service Soviet armored vehicles traveling on all avenues of approach into the battle position. In the third case, the battalion battle position had only one high speed avenue of approach on which TOWs could utilize their extended range. Therefore, all battalion commanders employed the TOWs in a pure company to cover this one avenue of approach.

c. On no occasion did a battalion commander attach one TOW platoon to each tank company, leaving the TOW company commander without a command. Nor did the Study witness a battalion commander who attached tank platoons to the TOW company.

d. Battalion Commanders most often attached one platoon of TOW's to the battle position commander who had secondary avenues of approach while the TOW company (-) operated under its company commander in support of the battle position commander who had the primary avenue(s) of approach to cover.

3. Employment of Tank Recovery Vehicles (VTR). This Study made no attempt to test the alternatives of organizing maintenance at both the company and battalion levels or organizing it only under battalion. The study, however, did test the employment and proper location for the battalion's heavy recovery capability.

a. Heavy recovery must accompany the tank companies directly into their battle positions. This is necessitated

by the requirement for fast response to recovery needs. The pace of every battle was so fast there was insufficient time to call for recovery to come forward from the trains location to recover disabled tanks; the VTRs could not reach company battle positions before the companies had to abandon vehicles requiring recovery.

b. Within the company battle positions, VTRs must locate themselves as near the engaged tanks as a covered route of egress will allow. Normally, this meant the VTRs were positioned in a covered and concealed position about 100 meters behind the firing tanks. As soon as a vehicle was knocked out but did not explode, a VTR immediately hooked up and pulled the tank to the trains or elsewhere for cannibalization. If not extracted quickly subsequent Soviet fires usually destroyed the immobilized vehicle.

c. The Study Group assigned each battalion one VTR per company and two in general support. The battalion commander must apportion the VTRs among the companies based upon unit needs and particularly upon the potential difficulty the companies will have extracting from their battle positions. With only five or six VTRs, heavy recovery capability was overwhelmed within two minutes after initiation of direct fire on the initial battle position. Moreover, none of the VTRs had enough time to finish their first runs to the trains and return to the initial battle position before the U.S. force redeployed to subsequent battle positions,

abandoning vehicles on the initial battle position. If the U.S. Army plans to perform substantial battlefield cannibalization, and return tanks to battle, it must increase to at least eleven VTRs its organic heavy recovery capability within the Medium Tank Battalions. Furthermore, number of heavy equipment transports (HET) must increase and tactics of employment must change.

4. Battlefield Class V Resupply

a. Tanks

(1) In the longest, most hard fought battles (Scenarios #2 and #4: two reinforced Soviet tank regiments) the greatest percentage of main gun basic load that any tank expended was 24 percent. The least percentage that a tank still alive at the end of the battle fired was 14 percent.

(2) Commanders did not improve end of battle on board ammunition stocks by ammunition redistribution or recovery of ammunition from disabled tanks.

(3) Three major factors distorted ammunition expenditure rates in BATTLE: the game has near perfect fire distribution, once a tank kills another vehicle it immediately stops firing on that vehicle, and as soon as a Soviet vehicle is killed all U.S. tanks know that Soviet vehicle is dead and do not fire upon it further.

(4) If this analysis was 100 percent understated, even without including redistribution and recovery of ammunition, all of the tank battalion organizations could have

fought two more regiments before their tanks expended all of their initial basic loads of maingun ammunition. However, this Study determined that the Soviets would destroy every M60A1 in battle before any ran out of ammunition, regardless of the organization.

(5) This Study placed a basic load of eight rounds of HEP on each vehicle to start the active defenses. In no case did a tank ever use a HEP round; APDS and HEAT could service every target in the regiments.

(6) While white phosphorous rounds were not included in the tank basic loads, on several occasions a hasty white phosphorous smoke screen would have made it possible to extract exposed units that eventually the Soviets cut off and destroyed. Three to five white phosphorous rounds per tank would provide this necessary capability. Artillery and mortars must be relied on for the preponderance of smoke missions, but in a few situations neither artillery nor mortars are quick enough for the battalion's requirements.

b. TOWs

(1) With a basic load of ten rounds, TOW vehicles have barely enough ammunition to service all potential targets during a tank battalion's fight against the first echelon regiment. The TOW company averaged an expenditure rate of 40 rounds per tank regiment battle. At the end of the first echelon battle, the TOW platoon had an average of

five rounds remaining on each vehicle (although in certain iterations this average figure was as low as three rounds).

(2) As with tanks, TOW expenditure rates were distorted by near perfect fire distribution, no reengagement of a destroyed vehicle, and complete knowledge of a target's status.

(3) However, TOWs which suffered firepower kills immediately became mobile ammunition supply points and redistribution of TOW ammunition between and during battles was common.

(4) Consequently, if this Study understates the TOW expenditure rate by 100 percent, and this is not impossible, many TOW platoons will expend all of their basic load before the tank battalions battle against a first-echelon regiment is over.

(5) In all iterations, the U.S. battalion commander started a TOW ammunition resupply truck from the battalion ASP as soon as the battalion made contact with the Soviets.

(6) The U.S. Army should reconfigure the inside of TOW vehicles to carry as many as twenty basic load rounds, and U.S. battalion S-4s must be exceptionally alert to the Class V resupply needs of the TOW company.

c. Dragon

(1) The expenditure rate of Dragons was dependent on the terrain and their deployment by different commanders. Occasionally, Dragons never had an opportunity to engage;

however, under ideal employment conditions the 12 Dragons in the Infantry Company averaged an expenditure of 32 Dragon rounds against a Soviet tank regiment. Surviving Dragon teams averaged three of their original six rounds remaining at the end of the battle.

(2) The infantry platoons would most likely have a fair opportunity to recover a number of Dragon rounds from Dragon teams that were killed as well as an opportunity to recover Dragon trackers when Soviet machine gun fire killed a Dragon team (a common occurrence).

(3) The same distortions in ammunition expenditure existed with Dragon as with tanks and TOW.

(4) If the Study underestimated by 100 percent expenditure of Dragon missiles, the Infantry Company still had sufficient Dragons to participate in the entire defeat of a Soviet regiment. However, the Infantry Company must be totally resupplied with Dragons before it can fight a second regiment. The Battalion S-4 must plan for this resupply with pre-positioning, a dedicated truck with Dragon missiles, or other expedients.

d. Mortars

(1) Once the U.S. gained visual contact with the Soviets, mortar platoons could fire no more than two missions in support of the battalion (there were two to four volleys per mission). These missions, however, were exceptionally

critical to the course of the battle because the effective use of smoke was a vital element in the battalion commander's effective fighting of an active defense.

(2) No single mortar ever expended more than eight rounds during the battle against a single regiment.

(3) Consequently, Class V resupply of the mortar platoon is not a problem during the normal course of a battle against two or even three regiments.

(4) The standard basic load of the U.S. Army heavy mortar platoon does require basic reevaluation. Throughout the six scenarios, the mortar platoons fired twice as many HC smoke rounds as they fired high explosive rounds. The high explosive (HE) round is totally ineffective against armored vehicles, and the battalions only fired HE rounds at dismounted Sagger Teams. Moreover, the effectiveness and range of tanks and precision guided missiles guarantee that quickly responsive smoke is absolutely necessary to the successful prosecution of the active defense. Battalion commanders consistently relied more heavily on their mortar platoons to provide smoke than direct support artillery.

5. Smoke

a. When necessary, battle position commanders must smoke their positions in order to extract from these positions; however, commanders must be careful when using this technique. Quite often, smoking one's position to cover extraction

screens other battle positions and makes the U.S. fires less effective. Whenever possible, commanders should select positions that possess covered routes of egress, rather than relying on smoke.

b. One effective counter to tanks massed in a breakthrough formation was to place a smoke mission just in front of the attacking formation. This achieved three advantages: Soviet TC's and gunners lost their orientation on the terrain to the front while in the smoke, Soviet formations lost some of their continuity, and, most importantly, only part of the formation emerged from the smoke at any one time thus effectively piecemealing the force.

c. When the Soviet second regiment massed in a breakthrough formation, the combined fires of the entire regiment proved more than any alternative battalion organization could absorb. Under these circumstances, the U.S. battalion commander effectively used smoke to screen one Soviet battalion from participation in the battle until the U.S. battalion had serviced the other battalions of the Soviet regiment.

6. Preparing Hull Defilade Positions for Armored Vehicles

a. In order to withstand preparatory fires with minimum losses and to improve survivability from direct fire, individual vehicles must have hull defilade positions dug for them. On the initial battalion battle position, 132 positions are needed just to provide each TOW and Tank vehicle of a 54 tank battalion with an initial and alternate position.

If each platoon has two platoon battle positions in the initial battalion battle position (the bare minimum for current doctrine), the organic and attached earth moving equipment must dig 264 vehicle fighting positions.

b. The present battalion organization provides for three dozer tanks per battalion, and, with an engineer platoon in direct support, the battalion could expect earth moving assistance from one bucket loader and possibly a bulldozer from the company in direct support of the battalion's parent brigade. In an emergency M-88 recovery vehicles can dig hull defilade positions; however, they would most likely be totally committed to supporting the maintenance effort. Given six hours to prepare for battle, each piece of earth moving equipment would have to prepare one hull defilade position every 7 to 8 minutes (including transit time between positions), an absolute impossibility even under ideal maintenance and ground conditions.

c. One solution is to modify one tank per platoon to employ a dozer blade:

(1) Under a reconfigured tank battalion, 4-3-4, each dozer tank would prepare eight individual vehicle fighting positions to provide each tank with an initial and alternate position. This effort would require no transit time between platoon battle positions. (The engineers could prepare the smaller positions for the TOW tracks.)

(2) If the battalion had six hours to prepare for battle, each dozer tank would have to prepare only one tank position every 20 minutes (to include transit time between positions) in order to provide each platoon with two fully prepared battle positions in the initial battalion battle position.

Operational ready rates for tank dozer blades must increase for this solution to be viable. The greater density proposed by this solution would assist by justifying PLL stockage of dozer parts. Better training would help too.

7. Mine Warfare and Barriers

a. The type minefields that a direct support platoon could emplace do not constitute a barrier to a Soviet battalion employing breakthrough tactics. Platoon laid minefields are so small that Soviet battalions are already into them and sometimes even substantially out before the Soviets are aware of the minefield's presence. Therefore, battalion commanders should site this type of minefield not to channelize the Soviets but rather to kill Soviet armored vehicles.

b. The basic load of anti tank mines in the tank battalion are of the incorrect type. Pressure, tilt rod, and magnetic anti tank mines are excellent mines for open terrain, extensive minefields; however, the tank battalion does not have sufficient mines in its basic load to emplace such a minefield of any consequence nor does it have the time and personnel to emplace it.

c. The Medium Tank Battalions in Europe do have a need for mines. In constricted areas such as trails, roads, and streets, battle position commanders can effectively use mines to block, slow, and hinder Soviet track vehicle movement. For this mission the Off Route-Ambush mine is much more effective than pressure, tilt rod, or magnetic mines which are nearly impossible to use with efficiency in these hard surface locations.

d. Due to the fast pace of the battle, barriers need only slow a Soviet force. Barriers close to the battalion battle position proved of great benefit when they delayed the Soviet force for as little as four minutes. Barriers such as those emplaced on wooded trails and roads did in fact channelize the Soviets.

e. To improve the barrier construction capability of the Medium Tank Battalion, each vehicle in the scout platoon and two tanks in each platoon should have chain saws. For the tank platoons, this could also significantly improve their ability to camouflage their vehicle fighting positions. Each infantry squad should also have one chain saw which it could use not only for barriers but also to prepare strong points.

f. This study did not include FASCAM (Copperhead) ammunition in the basic loads of the 155mm howitzer battalions. On numerous occasions, however, if the U.S. had possessed FASCAM the forward observers could have used these artillery

delivered mines with devastating effect. In their tightly packed, relatively inflexible formations, Soviet tank battalions are excellent targets for a rapidly responsive artillery battery armed with FASCAM ammunition. A particularly effective use of FASCAM would be to mix it with smoke making the detection by the tank commanders and drivers of individual mines nearly impossible.

8. Active Defense Engagement Techniques

a. The answer to the question of when to open fire is a function of the size of the Soviet force attacking:

(1) Against Soviet units of battalion size, U.S. company or slightly greater sized battle positions should initiate engagement at the greatest range possible. This technique takes maximum advantage of the following:

(a) The comparatively greater accuracy of U.S. anti-tank systems at long range,

(b) The extreme difficulty that the Soviets have acquiring any targets at long range (i.e., target acquisition at ranges greater than 2000 meters, particularly hull defilade targets, requires the use of binoculars, an almost impossible feat in a tracked vehicle moving cross country).

(c) The geometric and tightly packed pattern of Soviet vehicles in a breakthrough formation makes long range U.S. target acquisition much easier. The "predictability" of Soviet formations assists U.S. tank commanders and gunners in "knowing where to look" for Soviet vehicles. The rigidity

of these formations do not allow the Soviets to take full advantage of the natural cover of rolls and folds in the ground.

(d) The fire distribution system used by U.S. platoons is superior for servicing many targets at once (i.e., the Soviet system requires the platoon leader to first acquire the target, the platoon leader then engages the target, and finally the other two tanks in the platoon join in the engagement until the target is destroyed).

(2) Against Soviet formations of company size or smaller, the best engagement technique is to allow the Soviet formation to close to approximately 1000 meters in an open piece of ground before initiating direct fire.

(a) At these shorter ranges, the lethality of the first rounds of U.S. systems is so great that the U.S. battle position can totally destroy the Soviet formation before the Soviets can return effective fire.

(b) If the U.S. force engages at maximum range, the Soviet company operating independent of its battalion possesses enough flexibility to use the terrain to avoid annihilation and in the end will not only survive but report the U.S. position.

b. U.S. battle position commanders, particularly company battle position commanders, must endeavor to initiate direct fire simultaneously with all armor-defeating systems.

(1) Piecemeal engagement by U.S. systems in a company battle position should be avoided at all costs.

If a company opens fires by platoon, the platoon firing first must absorb the concentrated return fire by the attacker and this invariably has a devastating effect.

(2) Opening fire piecemeal alerts the Soviet battalion to the location of the company battle position making subsequent target acquisition substantially easier.

(3) Volley fire creates a greater shock effect on the attacking formation.

(4) Volley fire kills a much greater number of Soviet systems quickly before these can ever return effective fire.

c. If U.S. vehicles spend no more than 25 seconds in a vehicle fighting position before backing off, they should first engage the Soviet tanks before they complete the annihilation of the attacking Soviet force by engaging and destroying the BMPs. This fire distribution technique works particularly well because the flight of Sagger missiles is so slow that, even if the Soviets are granted instantaneous target acquisition, the U.S. tanks and TOW's have 25 seconds at a bare minimum to complete one or two engagements and back into defilade before the Sagger missiles can reach their fighting position. If the U.S. vehicles attempt to sit in one position too long during their engagements, they can expect to suffer a fair number of casualties. The U.S. force must destroy the Soviet tanks first. If the Soviet tanks close to within 1200 meters, they will take a heavy toll of

the U.S. vehicles. The BMPs, however, start to lose effectiveness as they close below 1200 meters, and between 1200 and 800 meters, the BMP is particularly vulnerable. Therefore, the U.S. force can wait, with some profit, until the BMPs in a Soviet Battalion are much closer.

d. Numerous iterations conclusively demonstrated that the defender should not fight the second regiment on the initial battalion battle position from which he defeated the first regiment.

(1) The defender has lost all advantages of surprise on his initial battalion battle position. With better intelligence, the Soviets employ devastating preparatory fires and their suppressive smoke and high explosive artillery severely restrict intervisibility.

(2) Residual Soviet forces from the defeated first regiment cause a steady and debilitating attrition of the otherwise victorious U.S. battalion. On a second battle position the U.S. battalion regains most of the advantages of surprise it had on its initial position. Additionally, good intelligence is available from battalion scouts still on the initial battalion battle position about the second regiments advance.

e. The U.S. battalion should not totally surrender its initial battle position just because it has defeated the first regiment attack and is moving the bulk of its forces to a second position. If the Soviets do not pass a second regiment

through their first defeated regiment, the U.S. Brigade Commander may elect to counterattack from this initial battle position, and the U.S. battalion has real advantages in an attack from a position of contact. Therefore, the U.S. battalion should maintain contact and control of the initial battle position with a company size force until it is sure the Soviets will attack through the position with a second echelon.

f. When lightly armored vehicles have revealed their platoon battle positions to the Soviets, they cannot afford to remain in these positions more than four minutes. If they remain longer than four minutes, soft skin vehicles become highly vulnerable to Soviet multiple rocket launched artillery and other heavy artillery.

9. Scout Platoon

a. In the active defense, the scout platoon is an absolutely essential element in the battalion. The scout platoon must keep the attacker's reconnaissance company from discovering the location of the battalion's initial battle position in order to retain surprise and avoid the effects of devastating indirect preparatory fires.

b. The active defense deploys almost all of the battalion force on the most likely avenues of approach. The scout platoon is essential in securing the battalions flanks, not as fighters, but to serve as eyes and ears for the battalion commander.

c. In the active defense the scout platoon should be organized so as to provide reconnaissance and economy of force missions.

10. Heavy Mortar Platoon

a. The mortar platoon plays a critical role in the active defense by providing smoke during daylight and illumination at night.

b. In order to add effectiveness, this Study increased the heavy mortar platoon to six tubes. This change provided one third more support and allowed the heavy mortar platoon to split their firing into two effective sections while keeping all six tubes in the same location. Six tubes allowed the platoon to support two company battle positions simultaneously with effective smoke or illumination.

c. The mortar platoon could operate from geographically split platoon sites but the FDC would have to be augmented. Splitting the platoon, however, does make it less vulnerable to counter mortar fires.

11. The Soviet Army made a major systems design error with its BMP that the U.S. Army should avoid.

a. The BMP while a fine armored personnel carrier has too many non-complementary weapons systems on the vehicle.

(1) The Sagger missile is the Soviet Army's primary long range anti-armor precision guided missile; however, when the BMP is in a good position to launch this missile

(1400 to 3000 meters) it is too far away to serve as an effective assault personnel carrier.

(2) When the Soviet Battalion is in the assault, the BMF closes to a range where the Sagger is totally ineffective.

(3) Fortunately, neither Soviet tactics nor the Soviet battalion organization allow a battalion to split its assets between assault units and overwatching units, and consequently when the Soviet battalion most needs the support of long range anti-armor missiles, the battalion is totally without this support.

b. While the same track bed may serve equally well as both an assault personnel carrier and as a precision guided missile launcher, the two functions are totally separate organizationally and geographically on the battlefield. The U.S. Army must keep this in mind when it designs its forces for the future.

12. The U.S. Army is currently underutilizing much needed tanks in order to provide carriers for Artillery Forward Observers (FO) and Forward Air Controllers (FAC).

a. When the FOs and FAC were in the best location from which to control their indirect fires, they were in an almost impossible position from which effectively to engage targets with their tanks' mainguns. Consequently, a number of tank systems in the Medium Tank Battalion were underutilized as battlefield killers.

b. Furthermore, in these Ideal Artillery and Air Support control locations the FO and FAC were too far from Soviet tanks to receive direct fire, and therefore, the FO and FAC did not need the direct fire protection afforded by the tank's heavy armor.

c. Only when the situation began to get desperate would the company and battalion commanders employ the FO and FAC tanks in the firing platoon battle positions.

d. Field experience has often shown that FO's and FAC's, lacking broad experience in fighting tanks, make inadequate tank commanders.

e. An optimum situation would have the FO ride in the loaders hatch of the company commanders tank. He would not be the loader but rather the fifth man in the crew. Ordinance depots would have to remove ammunition storage racks beside the present radio mounts and install another radio mount for the FO's radio. This arrangement is a field expedient already used in some units, and this repositioning where it has already occurred greatly increased the responsiveness and contribution of artillery to the battle.

f. The FAC can use an armored personnel carrier as his battlefield vehicle with the same efficiency as a tank.

g. The U.S. Army should organize the additional tanks generated by this rearrangement into more tank platoons and companies.

ANNEX S

SENSITIVITY ANALYSIS COMPUTATION

ANNEX S (Sensitivity Analysis Computation)

$$1. \text{ Degree of Allowable Error for 4-3-3} = \frac{\bar{x} (5-3-3) - \bar{x} (4-3-3)}{\bar{x} (4-3-3)}$$

$$= \frac{30.65 - 23.18}{23.18}$$

$$= 32\%$$

$$2. \text{ Degree of Allowable Error for 4-3-4} = \frac{\bar{x} (5-3-3) - \bar{x} (4-3-4)}{\bar{x} (4-3-4)}$$

$$= \frac{30.65 - 12.1}{12.1}$$

$$= 153\%$$

3. Percentage of Normalized Power Lost

Scenario	5-3-3	4-3-4	4-3-3
#1	41.3	3.0	15.9
#2	68.2	21.2	45.4
#3	7.1	3.2	11.7
#4	37.4	21.4	47.6
#5	18.2	13.0	10.6
#6	11.7	10.7	6.9
TOTAL	183.9	72.6	139.1
N	6	6	6
\bar{x}	30.65	12.1	23.18